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THE LOA VIADUCT, THE HIGHEST IN THE WORLD.

WE give an illustration of the viaduct over the river Loa, on the Antofagasta Railway, Bolivia, which is, we believe, the highest railway bridge in the world. Through the courtesy of Mr. Edward Woods, Past Pres. I.C.E., we have been enabled, says the *Engineer*, from which our engraving is taken, to select the salient points of interest in the design, which we have laid before our readers in our illustrations, and which will be understood without any very detailed description. There are, however, some points which we think are deserving of special attention.

The perspective view of the viaduct is from a fine drawing in the possession of Mr. Woods, the work of a prominent young artist, Mr. Dudley Heath.

The canon spanned by the Loa Viaduct is situated in the upper Andes, at an altitude of 10,000 ft. above sea level. It has been formed through solid rock, probably by the joint influence of volcanic action and the iceflows. Its sides are precipitous and rugged, and great difficulty was experienced in selecting a practical point of crossing for the railway. Some idea of the character of the ground may be formed from the fact that it was considered very good work for any of the surveying party to cross the canon in two hours. There is no available path up the canon; consequently all materials used in the construction of the viaduct had to be delivered on the seaward abutment, and the whole of the iron work for the piers had to be lowered into the gorge.

The work of locating the railway and selecting the point of crossing was undertaken by Mr. Josiah Harding, M.I.C.E., who was at that time the engineer of the railway in Bolivia. To Mr. Harding is also due the credit of proposing the general character of the structure, and fixing the positions of the piers.

After the main features of the proposed viaduct had been submitted by Mr. Harding to Mr. Woods, and approved by him as consulting engineer to the railway company, Mr. Harding returned to Bolivia, and took charge of the necessary masonry work for the foundations of the piers and the abutments. This work was executed in anticipation of the arrival of the iron work from England, and it is satisfactory to know that when the viaduct was erected there was not the slightest adjustment required in the foundations or the iron work.

After approval of the general character of the proposed viaduct, Mr. Woods undertook the responsibility of making the necessary calculations and designing the details, a work of no small magnitude.

The contract drawings, copies of which have been kindly placed at our disposal, show with what care every point in the design has been considered; they are, in fact, good examples of what such drawings should be, each separate junction in the piers and girders being shown in detail.

In the absence of trustworthy data as to the force of the wind during hurricanes, which sometimes occur of considerable violence, blowing up the canon, it was decided in making the calculations as to stability to take the maximum possible wind pressure at such an intensity as would be sufficient to blow a train of empty trucks off the viaduct, the condition of least stability being when the viaduct is loaded with an empty train. This pressure was carefully computed, and the result obtained adopted in the subsequent calculations for stability. Supposing such a pressure had at any time to be withstood by the viaduct—which is very improbable—there would then be a large margin of stability. It should be remembered in connection with the question of wind pressure that the weight of the atmosphere, at the great altitude at which this viaduct is erected, is only about two-thirds of that at sea level, the barometer standing at about 21 in. of mercury.

The following are some of the principal particulars of the viaduct:

Length between abutments.. ...	800 ft. 0 in.
Height from water to rail level...	336 " 6 "
Length of longest column	314 " 2 "
" " principal spans.......	80 " 0 "
" " pier spans	32 " 0 "
Width of platform over all......	13 " 0 "
" " center to center, main girders..............	8 " 10 "
Depth of main girders, centers of booms..........................	7 " 11 "
Batter of outer columns	1 in 6
" " piers..............	1 in 3
Gauge of railway...............	2 ft. 6 in.
Weight of iron work.............	1,115 tons.
Rolling load per foot......... ...	1¼ "

The viaduct was erected without any temporary staging, this being effected in the following manner:

A wire rope tramway was constructed across the canon, consisting of two of Messrs. John Fowler & Co.'s strongest steel plowing ropes spanning the gorge from side to side, being a clear span of 800 ft.; and on this aerial road a carrying truck was hauled backward and forward by steam winches placed upon the abutments; all the parts of the piers were launched on this tramway, and when over the places where they were required, were lowered by suitable tackle. The piers are constructed in stages, so that as each tier was completed, a working platform was formed for the construction of the next.

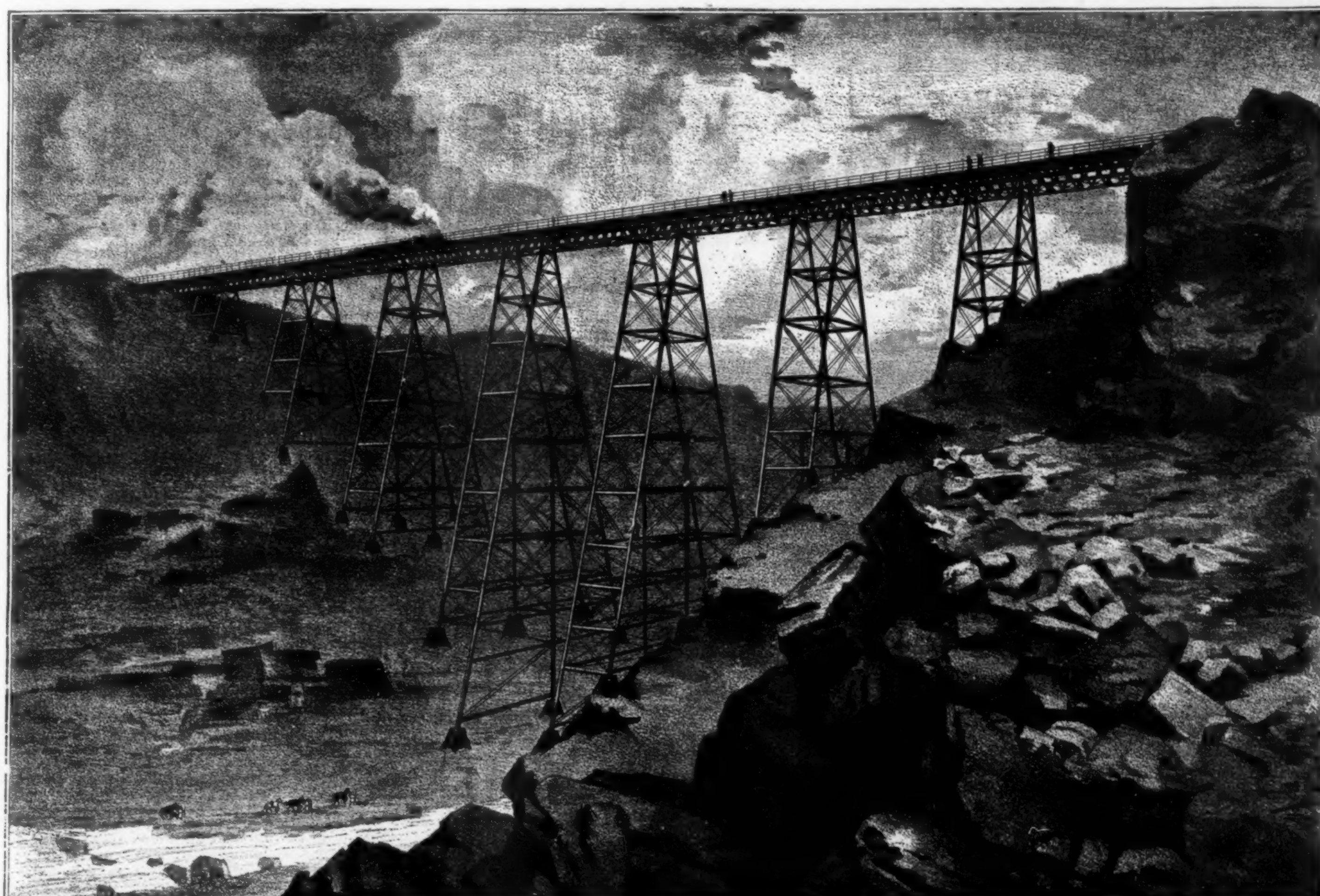
It may be interesting to mention that after the wire ropes were in place, it was decided to send a locomotive and a large quantity of the material required for the construction of the railway across the canon by the means they afforded, and this was safely accomplished. The locomotive was taken to pieces, but the weight of its boiler being much in excess of any part of the viaduct, the ropes were strained very heavily by its transit. However, they withstood this exceptional trial most satisfactorily.

As the piers were completed, the girders forming the superstructure were placed in position by means of a crane, sent out with the iron work from England, and constructed to lift the longest girders—80 ft. span—in one piece and place them in position.

This crane was worked by hand and made to run on a special line of rails laid immediately over the girders which were in place; it had an overhang of jib of 50 ft., and was tested with a load of twelve tons, the weight of each of the main girders being slightly under ten tons.

The girders were put together on the abutment and riveted up complete, and were then placed in position by the aid of the crane in a very few hours. In the construction of the main girders channel irons were very extensively used, which for small spans is found to be very economical, on account of the small quantity of riveting entailed.

The cross girders and rail bearers are of iron, the former resting on turned steel pins carried by steel castings on saddles, bridging the top boom of the main girders. Provision was made at one end of each main girder for expansion and contraction, as also in the



THE LOA VIADUCT, ANTOFAGASTA RAILWAY, BOLIVIA.

wrought iron rail bearers. One of the spans of each class was very severely tested before leaving England, and the results obtained were remarkably good.

The section of the columns consist of four rolled pillar iron sections, and four bars of 3½ in. by ¾ in., as shown in our illustration.

The method of joining the columns is very simple, and has been found to be most effective. It consists of an internal diaphragm of cruciform section, built up of three plates and four angle irons. These junction pieces were sent out riveted in place at the upper end of each column, thus forming a base or spigot for the following length of column to be placed upon or over.

The diaphragm junction pieces are each 4 ft. 8 in. long, the plates used in their construction being ¾ in. thick. The 3½ in. by ¾ in. bars are stopped at 2 ft. 4 in. from either end of each column, and the spaces between the flanges of the pillar irons, for this length, are occupied by the plates of the cruciform junctions, which plates are extended beyond the width of the column where necessary, and thus form wings or lugs, to which the main bracing of the pier is attached. All the tie bars, excepting the horizontal ones, are in pairs, and this was found to give much facility for the erectors to get about the work.

All tie bars are fitted with muff coupling boxes, so that they can be adjusted to the exact length required. It was a condition of the contract that a special hydraulic press should be provided by the contractors, capable of testing a length of column of 30 ft. 6 in. to destruction.

The results obtained from the tests made on two columns were remarkably satisfactory and uniform, there being practically no difference between the two. In one case the pressure was applied direct to the column section, and in the other to the junction diaphragm. In this latter case it was arranged that the whole of the pressure was conveyed to the column through the rivets connecting the diaphragm at one end, and transmitted through the bolts connecting the diaphragm at the other, the object being to prove the sufficiency of the connections. The general results obtained were as follows:

With a load of 600 tons, no measurable permanent distortion was obtained; with a load of 625 tons, a slight permanent deflection from the straight line resulted; and with a load of 650 tons, the column was crippled. The gross section of the columns tested was—

	Square inches.
Four pillar irons, each 7·5 square inches	= 30·0
Four bars, 3½ by ¾	= 10·5
Total cross section	40·5

It will thus be seen that these columns withstood, without permanent distortion, a stress of 14·8 tons per square inch of gross section—a remarkable result, seeing that the greatest diameter of the column—measured over the flanges—is one-eighteenth of its length. After the two columns were tested, as above described, they were further subjected to a falling weight test to prove the resisting power of the material to sudden impact.

The contract for the viaduct was secured by the Horseley Company, of Tipton, Staffordshire, and the firm executed the work to Mr. Woods' entire satisfaction. The materials employed, all of which had to stand most severe tests, and the quality of the workmanship throughout being of the highest class.

Each pier was temporarily put together and laid upon a level platform, in the bridge yard, with all cross bracing, struts, and ties in place, and then carefully checked as to dimensions.

The Horseley Company undertook to send two skilled men out to Bolivia to superintend the erection, and their choice fell upon Mr. Peter Fisher, as principal, and Mr. William Fisher, his brother, as assistant. How carefully the work had been executed here, and how good a choice the contractors made in their representatives, is shown by the following facts:

Before the work of erecting was commenced, Mr. Harding had given up his position in Bolivia, and Mr. Peter Fisher had therefore to take the responsibility of the erection.

He commenced rigging up tackle in Bolivia on May 2, 1887, the viaduct was finished on January 28 following, and the first train was run across on February 16, 1888. The above result was accomplished without the assistance of any skilled labor, as the only men available were such as could be picked up at the port of Antofagasta. They were mostly sailors, without any previous knowledge of iron construction.

Not only was the viaduct erected within the comparatively short time of rather over nine months, but it is a satisfaction to all concerned that it was completed without loss of life or serious accident. The number of men employed upon the work averaged thirty-five to forty, the greatest number at any one time being fifty-five. Trains run over the viaduct at speeds of about thirty miles per hour as a maximum.

We are indebted to Mr. W. H. Woodcock for the foregoing particulars, who, as Mr. Woods' chief assistant, was engaged upon the details of this important work.

[From the New York Tribune.]

THE NEW CROTON AQUEDUCT, NEW YORK.*

A walk through the new aqueduct was proposed. The first requisite was a passport, and to obtain it a visit was paid to the chief engineer, Alphouse Fteley, whose office is in the Stewart building. Mr. Fteley is as courteous as he is learned in his profession. The reporter was a little doubtful about the pronunciation of his name, and took care to prime himself before sending in a card. The elevator boy whispered in confidence that "everybody called it different," some "Eftilly," some "Eftly," some "Fitealy," some "Footly," a few "Te-ley." Mr. Frost, his private secretary, was appealed to. "Telly," he said, which seemed simple enough, and the reporter mastered it thoroughly. Mr. Fteley, who was exceedingly busy, regretted that he could not accompany the reporter on his tour. No one had yet walked through the tunnel, not even an engineer, not even that fine old soldier and gentleman, General Duane, who had been in the habit of making two or three subterranean expeditions a week. Four letters were written, similar to this:

CHIEF ENGINEER'S OFFICE—AQUEDUCT COMMISSIONERS.

A. Fteley, chief engineer,
George S. Rice, deputy chief engineer.

New York, Jan. 20, 1890.

Mr. Charles S. Gowen, division engineer, Sing Sing, N. Y.:

Dear Sir: This is to introduce Mr. —— ——, of the *Tribune*, who wishes to make a trip through the aqueduct tunnel and to visit the gate houses, etc. Please extend to him all possible facilities to visit the work under your charge. I am, respectfully,

A. Fteley, Chief Engineer.

The other three letters were written to George B Burbank, division engineer, Brewster's Station; Alfred Craven, division engineer, Yonkers; and Edward Wegman, Jr., division engineer, No. 324 St. Nicholas Ave.

"I shall also," said Mr. Fteley, "write personally to each of these gentlemen, telling them of your intended visit, so that they may be prepared to receive you."

This, however, proved unnecessary, as, on the next day, Mr. Rice, the deputy chief engineer, cheerfully consented to act as escort during the journey. The reporter suddenly found himself relieved of every embarrassment, Mr. Rice taking hold at once and arranging all the details of the trip. The first meeting was at the Grand Central Station on Thursday morning, January 23 The sun was just rising when the train reached Sing Sing. It was bitter cold. Two stout gray horses, a rockaway, and "Jim," the driver, were in waiting, and they whirled the tourists over the frozen roads in the direction of Croton Lake, seven miles distant. On the way Mr. Gowen, who has charge of the first fourteen miles of the aqueduct, was picked up. He is an engineer of acknowledged ability and few words. The city is largely indebted to him for the exposure of countless frauds in the masonry of the tunnel. A short stop was made at his office, where the vacant places in the rockaway were filled with tunnel toggery, then the drive was continued through frost-nipped valleys and barren hills, along the edge of the proposed Quaker Bridge Reservoir, which is to hold 30,000,000,000 gallons of Croton water when filled, and on to Croton Dam, where the great gate house stands in a niche blasted out of the solid rock of the hills. Here the tunnel was to be entered for the long journey.

GETTING INTO RUBBERS.

In a small frame house below the dam, used for an office, a complete metamorphosis was effected in the outward appearance of Mr. Rice, Mr. Gowen, and the reporter. Tweed trousers and diagonal coats were exchanged for corduroys which seemed to have had an intimate acquaintance with the country; light shoes were taken off, thick woolen socks were pulled over Lisle thread, and the feet and legs as high up as the hips incased in rubber boots, with innumerable corners and crevices and angles, and room enough for the foot to roam about promiscuously, excoriating heel, instep, and ankle bone regardless of the future. Mr. Rice clung to his sealskin cap, but his companions laid aside their derbies and plunged head and ears into rubber sou'westers. Rubber coats completed the outfit. Mr. Rice looked partly respectable, Mr. Gowen looked like a battered tar on a weather-beaten whaler, the reporter looked like a tatterdemalion scarecrow in a watermelon patch. The trio were a sight to frighten darkness out of the tunnel. But, inasmuch as they were impervious to moisture and indifferent to silicate of magnesia, they were content. Mr. Gowen padded his coat with candles, shouldered a scoop-like reflector that swung in a fork at the end of a pole, and took up the march.

THE GREAT GATE HOUSE.

The gate house through which the water is admitted to the aqueduct is an imposing structure, almost overpowering in its immensity. It sits in a great hole blasted in the solid rock 100 feet below the old dam. Far above the level of the water is the upper inlet, a short tunnel about ten feet in diameter. Below this is the middle inlet, of the same size. The uninstructed wonder what those two big holes gaping there in the side of the hill can have to do with the water supply. They would never guess that this massive gate house was built in view of the construction of Quaker Bridge Dam, and that the two inlets will be of no sort of service till such time as that dam may be constructed. And there is still another inlet, forty-four feet beneath the upper one, through which not a drop of water can flow till the Quaker Bridge Reservoir is completed. The water above the present dam reaches the gate house through what is called the by-pass inlet, a tunnel near the bottom of Croton Lake. This by-pass was constructed under many difficulties. In order to prevent the water in the lake from interfering with the work, a wall of rock was left standing on the bank, between the portal and the lake, till the tunnel was finished and the gates were closed. Then a single blast of 600 pounds of dynamite blew the wall into fragments, and the channel was complete. Mr. Rice, Mr. Gowen, and the reporter stood on the wall near the portal and watched a diver at work removing pieces of stone from the bottom. The lake was covered with ice as he worked.

QUAKER BRIDGE DAM.

Quaker Bridge Dam, the site of which is five miles south of Croton Dam, is to be 264 feet high and 1,500 feet long, and the water behind it will form a lake sixteen miles long, and so deep that Croton Dam, from which our present supply comes, will be submerged to a depth of thirty-four feet. Scores of farms and farmhouses in the valley will have to be abandoned when the water begins to rise. The view from the upper inlet of the gate house is picturesque. The cows are moodily browsing the frosted grass in pasture lots separated by stone fences which go zigzagging up and down and across the peaceful dale. The houses and barns are asleep, and their inmates, too, for all the life that may be seen about them. The edges of the spillways of the dam are huge chunks of ice, between which the water is hurrying down the slope to the Hudson, robbing the city of millions of gallons daily. The scene, as far as eye can reach, is worth gazing on for an hour; ere long it will be a barren waste of waters.

WHERE THE WATERS ARE TAMED.

Men are busy in the gate house fixing the gear for raising and lowering the gates. One man, by turning a small wheel, is enabled to lift tons. The floor is of perforated iron plates, through which, in abysmal depths below, may be seen the vast stone chambers in which the waters are to gurgle and boil and rage as the engineer arrests their mad sweep; for it would not do to open wide the gates and let the mighty stream tear through the house at its own pace. It must be taken early in hand and quieted, controlled, and tamed before it is permitted to pass the portal of the aqueduct. When the by-pass is opened there is a terrific onslaught from the lake, but the massive walls resist it, till the water in the first chamber is on a level with the crest of the dam. Then the great gates near the bottom of the chamber are cautiously opened. The water under heavy pressure sweeps through into the second chamber, roaring terribly, but here it is again checked, only to be allowed to pass on when quieter into a third chamber, and a fourth. In the last chamber it passes through enormous strainers of brass, which keep back all the trash that may have drifted in.

The gate house is a study in itself. It is a masterly piece of engineering. Like Solomon's Temple, it was built without the sound of chisel or hammer on the stone used in the construction of its walls. Every piece, designed in the office of Mr. Fteley, was cut by quarrymen in Maine to fit a certain place, and the masons had only to lay the courses according to specifications and bind them together with cement.

Through a hole in the floor the tourists plunged down, down, down a winding stair, till they were dizzy with winding; then down a ladder; then down a rope, sailor fashion, hand under hand till they stood beneath the great brass strainers. Before them, less than six feet away, was the portal of the aqueduct, big, hollow, black; shaped like a horseshoe set up on its heels, wide enough for ten men to walk abreast and tall enough for a locomotive with funnel erect. Candles were lighted, hats were pulled down, and bootlegs pulled up. The tourists stepped inside, gave a last look at the gate house, and wheeling round started for Central Park, thirty-three miles away.

THROUGH THE DIAPHRAGM.

Fifty feet from the portal the aqueduct is planked up temporarily from the bottom of the invert to the crown of the arch, and entrance to the tunnel is gained by a narrow little door through which the wind hums mournfully, putting out the lights as they attempt to pass. Once inside, the door is closed, the wind is dammed, and the candles are relighted. The hole is as dark as Erebus. The pupil dilates slowly, but by and by takes in the empty blackness. There is no perspective. Everything is a blank fifty feet away. The side walls, the floor, and the arch near at hand are easily discernible, but they are black and reflect not. Directly ahead the eye looks into a nebulous cone, which constantly advances, ever beckoning the traveler on, like an "ignis fatuus." The tunnel starts eastward, but curves rapidly to the south, turning an angle of 40 degrees in a distance of 200 feet, then it starts off on a tangent nine and a half miles long. On the uninitiated this curve produces a curious hallucination. It seems never to stop, but curves on and on till it becomes a spiral. The eye loses all sense of direction. If the flicker of a candle is seen far beyond the apex of the cone, it is the most natural thing in the world to step to the opposite side of the tunnel in order to get a better view of it. This is done unconsciously again and again, silly as it may seem.

The party walks on with rapid, steady—no, not steady—stride. The bottom of the tunnel is like the bottom of a washbowl, a depressed arch inverted, therefore briefly termed the invert. The center is eighteen inches lower than the edges, consequently the water that leaks in forms a little river, which has a sloping bank on either side. Walking in this river soon becomes a labor. Mr. Rice and Mr. Gowen walk on the banks, which are in places so narrow that there is room for only one foot. They are used to it, and seem to get on easily with a sort of hopstep, one foot always being lower than the other, owing to the slope. The reporter tries it, and sprawls about helplessly, scraping his shoulder against the wall one moment and the next tobogganing down to the middle of the river, waving his arms wildly for a balance. After many scrapes and slips he learns the trick walking on the bank, and progress then is not so difficult. The heels of his borrowed boots, long accustomed to slip and slope, have been worn to fit the invert, and as soon as he discovers this, his troubles lighten. But he finds a frequent change of bank necessary to his happiness. By long hopstepping on the right bank his left leg becomes elongated, while his right becomes foreshortened to an alarming degree. He begins to feel like a man with white swelling or hip disease. To change this he fords the stream and obtains a change of leg, the right now suffering elongation, and the left foreshortening.

HOW THE TUNNEL WEEPS.

The water, which at the portal was only two inches deep, gradually deepens, encroaching always on the narrow banks. The tunnel weeps continually. It is excessively lachrymose. Fortunately, owing to its peculiar construction, it drinks all its tears, which join its little river, swelling it all the time. The eyes with which it weeps are rightly called weepers, being small rectangular openings in the side walls, through which all the water collected and collecting on the outside of the masonry pours into the inside. By means of them many thousand gallons are added to the Croton supply daily. Often did the reporter kneel beside these weepers and fill to the brim with pure spring water, fresh from the heart of the hills.

Progress is measured by white porcelain plates having black figures burned into them and screwed to the last wall every 500 feet. The portal at the gate house being at zero, each plate represents a multiple of 500. All will be under water when the great gate swings open, but they can be easily found when needed. The plates are called stations. When an engineer orders that a leak at Station 250 plus 75 be stopped, the contractor knows that the spot is exactly 25,075 feet, a little less than five miles, from the gate house.

As the tourists walk they talk. Their voices are low, yet the tunnel hums as a beehive hums when its colony is agitated. Occasionally, in the course of its modula-

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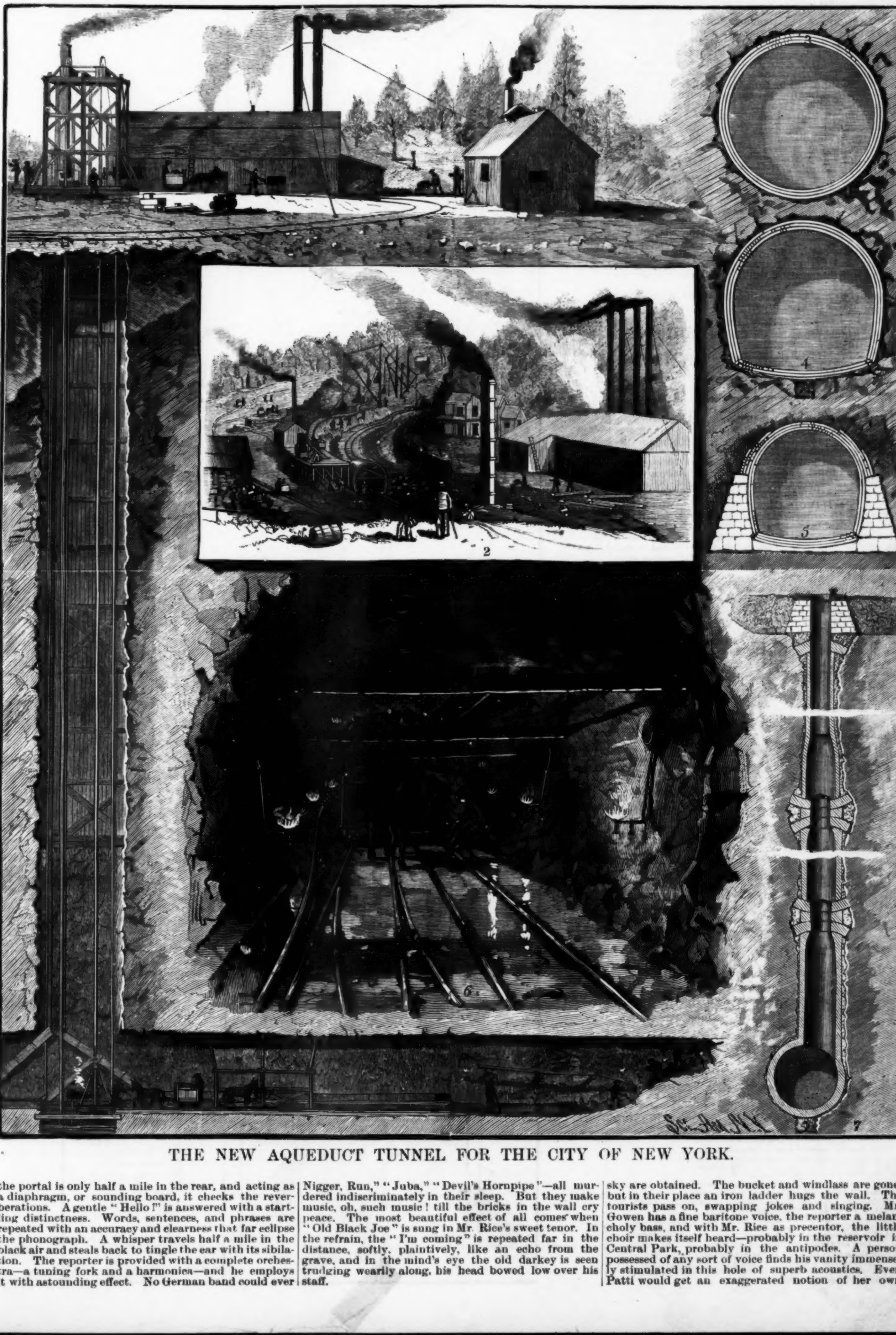
* Additional descriptions and illustrations of this great aqueduct work will be found in our SUPPLEMENTS 471, 558, 560, 679.

tions, a voice strikes a certain pitch which causes an intense vibration.

"The tunnel has a key of its own," says Mr. Rice, and forthwith he proceeds to search for it in all the compass of his voice. The "do-me sol-do" is given in every key, major and minor, but the echo spoils the chord, and little is gained. The wooden partition near



THE NEW AQUEDUCT TUNNEL FOR THE CITY OF NEW YORK.

the portal is only half a mile in the rear, and acting as a diaphragm, or sounding board, it checks the reverberations. A gentle "Hello!" is answered with a startling distinctness. Words, sentences, and phrases are repeated with an accuracy and clearness that far eclipse the phonograph. A whisper travels half a mile in the black air and steals back to tingle the ear with its sibilation. The reporter is provided with a complete orchestra—a tuning fork and a harmonica—and he employs it with astounding effect. No German band could ever hope to flood the earth with music as that harmonica in B does. If there be spirits in the bowels of the earth they must dance to the tunes that confuse and split the erstwhile solemn air. The tunnel quivers and the big hills groan with the agonies of "Johnny, Get Your Gun," "Old Dan Tucker," "Johnny Ryestraw," "Billy in the Low Ground," "Pop Goes the Weasel," "Run, Nigger, Run," "Juba," "Devil's Hornpipe"—all murdered indiscriminately in their sleep. But they make music, oh, such music! till the bricks in the wall cry peace. The most beautiful effect of all comes when "Old Black Joe" is sung in Mr. Rice's sweet tenor. In the refrain, the "I'm coming" is repeated far in the distance, softly, plaintively, like an echo from the grave, and in the mind's eye the old darkey is seen trudging wearily along, his head bowed low over his staff.

A TUNNEL IN F MAJOR.

At station No. 50 plus 98 a dull ray of light glances along the east wall. It steals down through shaft No. 1, a round well five feet in diameter and 350 feet deep. It is covered over at the top with thick plank, but there are cracks through which glimpses of the silver sky are obtained. The bucket and windlass are gone, but in their place an iron ladder hugs the wall. The tourists pass on, swapping jokes and singing. Mr. Gowen has a fine baritone voice, the reporter a melancholy bass, and with Mr. Rice as precentor, the little choir makes itself heard—probably in the reservoir in Central Park, probably in the antipodes. A person possessed of any sort of voice finds his vanity immensely stimulated in this hole of superb acoustics. Even Patti would get an exaggerated notion of her own

lofty vocalism were she induced to sing here under the earth, and $500 a note would not fetch her afterward in the Chicago auditorium, or anywhere else.

Imagine the tunnel a grand organ pipe into which a flood of harmony is poured and hermetically sealed. Imagine yourself gifted with the power to break the seal and then to lie down in a quiet spot and drink in for ages the escaping melodies. In the oppressive silence deep down under the hills the sounds seem waiting for a voice to stir them to action. A shout alarms them painfully, they go dancing and ricocheting noisily down the pipe, melting slowly away till lost in the accumulating miles of brick and mortar, or till wafted up an open shaft to vanish in the air of the hill tops.

At station No. 150, nearly three miles from the portal, beyond the range of the echo, repeated experiments discover the tunnel to be tuned to the key of F. There can be no mistaking it. No matter where the voice may wander, when it stumbles on that particular key the tunnel makes instantaneous response: a response gracious, generous, soulful. It warms the blood with its vibrations and fills one with an ecstasy of delight. The chord, sung moderately loud, one tone after another, in sharp staccato—"do mi sol do"—rolls away rapidly through the ringing hall. For a few seconds each tone retains its distinct individuality. The first uttered seems to be chased by the others. Soon it is overtaken by "mi," then by "sol," then by the octave "do." The four then sweep on together in delicious harmony. Ear never listened to a more enchanting sound. For sixteen seconds the concord lingers, then a dissolution takes place, the tones parting company even as they joined, each resuming its individuality and gradually passing away. The tourists drink of this intoxicating draught till their souls are bursting.

A tunnel in F major is a masterpiece of which New York can never feel too proud.

FALSE WORK.

The aqueduct along here is the same in width as in height—thirteen and a half feet. From the portal, all the way down, the side walls and the arch have a mottled appearance, caused by patches of new masonry placed in the old. So extensive were the frauds in the masonry, that the completion of the aqueduct has been retarded over a year. The entire tunnel has been in a large measure reconstructed at the expense of the contractors, the extra cost being some $2,000,000. The work was an outrageous swindle from beginning to end, as can be proved, as will be proved, when the claims are presented for final adjustment.

The engineers had over 225,000 holes cut through the walls of the tunnel, and each hole exhibited a steal. Thousands of cubic yards of air were paid for at the rate of $5 a yard, air that was supposed to be masonry. There were two methods of repairing the faulty work, one by tearing down the walls and rebuilding them, the other by cutting holes through the lining, which was sound, and filling the spaces behind them with rubble masonry. The latter was decided upon, and the 225,000 holes were cut. When the spaces were filled with loose rock, cement in liquid form was forced into the crevices and interstices by means of a powerful air pump working at a pressure of forty to ninety pounds. In a few weeks this cement will dry out and "set," locking the rock together into a firm, immovable mass. This method is called grouting.

While repairs were being made on Mr. Gowen's division, one of the inspectors contributed the following lines to enlarge the hilarity of the occasion. There is reason in his madness—more reason than rhythm.

The characters mentioned are all well known on the work.

KEEP UP THE GROUTING ALL THE WHILE.

Air: From the Compressor.

One day there came around an engineer named Gowen,
And he said: "All the backing must come out."
But he came another day, and he had another way,
And he said: "I guess we'll fill them up with grout."

"Make them put in neat cement if it costs them every cent,
Forty thousand barrels to the mile."
Then old Arnold got a funnel and took it down the tunnel,
And they've kept up the grouting all the while.

The company bought a lot of tools, bought another hundred mules,
And a string of carts that reached almost a mile.
With twenty barrels to the load, they came up the Sing Sing road,
To keep up the grouting all the while.

If you want to do it neatly, scientific, and completely,
If you want to grout it so it'll never "spile,"
Go and get a thousand dippers, give them to a thousand nippers,
And let them keep up the grouting all the while.

How the Guineas flocked around when they heard the whistle sound,
And they marched upon the cage in single file;
And as the cage went slowly down, there arose a mournful sound,
"We must-a keep up-a the grout-a all-a the while."

When O'Grady's light went out he fell down in the grout,
And he floated all around quite awhile;
But a Guinea five feet tall poured him in behind the wall,
And they kept up the grouting all the while.

Then McDonald came along, and he was glad that he was gone,
For he said he thought O'Grady acted vile,
He said he didn't care a cent; O'Grady was cheaper than cement,
To keep up the grouting all the while.

One day Peter J. O'Flynn he condemned every —— —— Guinea,
For he said they couldn't grout in proper style;
And the walking boss said, "—— it," but they got another bucket,
And they kept up the grouting all the while.

One night Gilchrist came along, singing some religious song,
And he hung about the tunnel for awhile;
And then backward he did creep, caught the inspector fast asleep,
But they kept up the grouting all the while.

It was Kellogg made the hole, for he carried the sounding pole,
And he handled it in true artistic style;
Then along came Slingerland, said he guessed he'd take a hand,
To keep up the grouting all the while.

Then the big and bold John Tarn said he didn't give a darn,
And on D. D.'s face there came a wicked smile;
And he said out loud to Bruff, "—— it, they can't make cement enough
To keep up the grouting all the while."

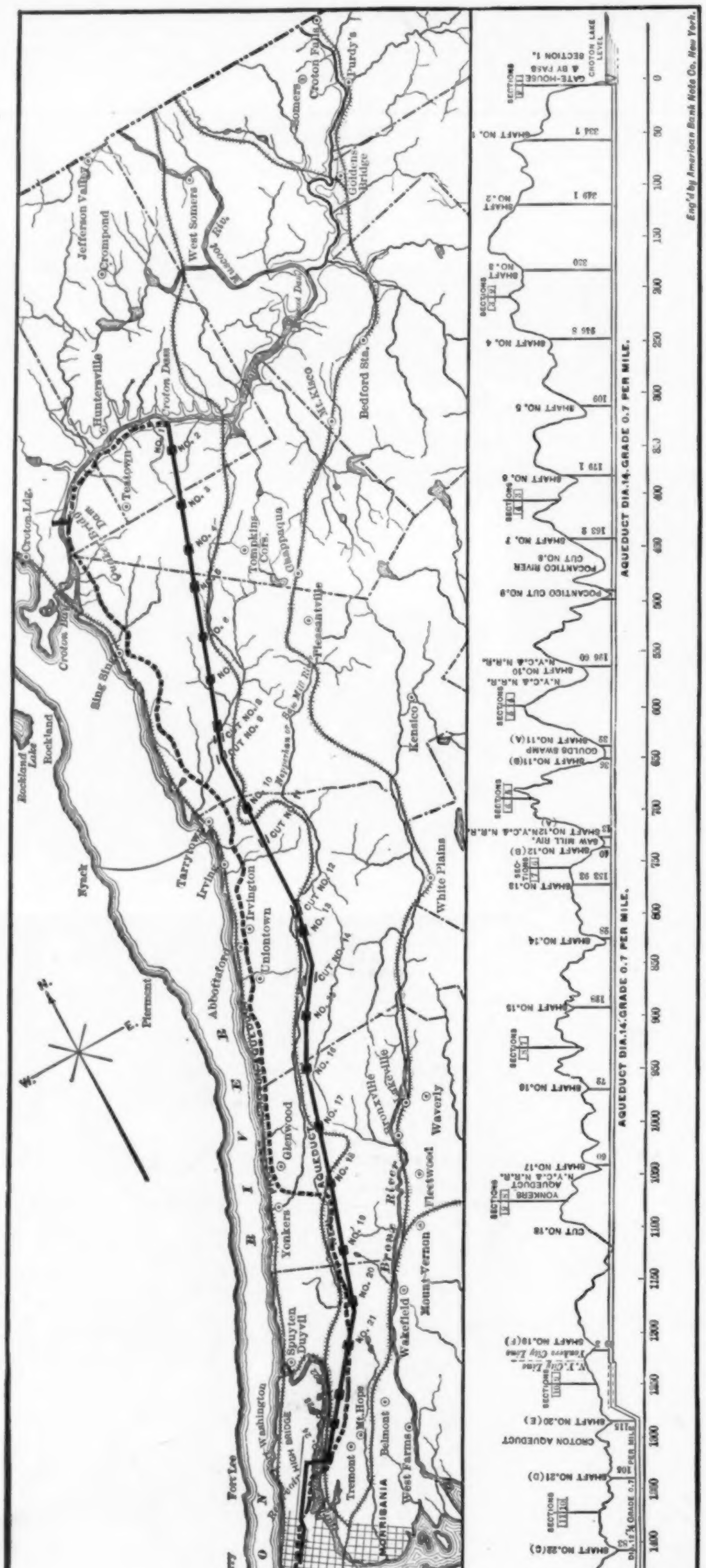
How the engineer had to hustle! Even "Steve" got on his muscle.
Orcutt couldn't get his hair cut for awhile;
Moore at "One" said: "Now yew bet I can't smoke a cigarette,
While they keep up this grouting all the while."

Then the senators came down to take a look around,
And they winked with one another with a smile;
And they slid into the bar—not for a good cigar—
But to keep up the grouting all the while.

And poor Virgie Worthington, time-keeper at Shaft One,
Said: "This grouting will all my pleasure spile;
Some fellow'll take my girl away, while I at the shaft must stay,
If they keep up the grouting all the while."

So the work goes right along, whether it's just or whether wrong,
Day by day Seitzinger's records go on file;
And in 1901 the tunnel may be done,
If they keep up the grouting all the while.

Now this song is all in fun, and at last it's nearly done,
And the author's going out to get his "ile;"
And he'd ask you all to go, if it was pay day, "don't yer know,"
And keep up the grouting all the while.



MAP AND PROFILE OF THE NEW AQUEDUCT, NEW YORK CITY.

BIG FIGURES TO CONTEMPLATE.

The estimated cost of the aqueduct was less than $15,000,000. Before it is completed nearly $23,000,000 will have been expended.

Work on the aqueduct was begun in January, 1884, and will probably be finished next June—six years and a half.

The total length of the aqueduct from the Croton Lake gate house to the Central Park gate house is thirty-three and an eighth miles.

The flowing capacity of the aqueduct from Croton Lake to the proposed reservoir at Jerome Park is 318,000,000 gallons every twenty-four hours; from Jerome Park to Central Park, 250,000,000 gallons every twenty-four hours, leaving 68,000,000 gallons to be distributed through the annexed district.

The amount of brick work laid in the aqueduct is estimated at 312,258 cubic yards, or about 163,000,000 bricks, which would build thirty-three structures the size of the *Tribune* building.

The total area of the inside surface of the aqueduct from Croton Lake to the One Hundred and Thirty-fifth Street gate house is equal to 7,092,823 square feet, or 162 4-5 acres; or about one-fifth the area of Central Park.

The amount of material excavated in the construction of the aqueduct, added to the masonry placed, exceeds 3,250,000 cubic yards, which is equivalent to 83 per cent. of the volume of the great pyramid of Cheops. This material would be sufficient to build a wall ten feet thick and fifty-five feet high around Manhattan Island, thirty miles in length on the water front.

The amount of dynamite used in blasting on the aqueduct, exclusive of the amount used in sinking the shafts, was over 5,800,000 pounds—nearly 3,000 tons.

The water that flows through the aqueduct every twenty-four hours is equivalent to a stream fifty feet wide and ten feet deep, flowing 59 ft. 1 1-5 inches a minute, or about one foot a second.

NEED OF THE NEW AQUEDUCT.

These figures and comparisons are given in order that this great public work, one of the greatest public works ever undertaken since the world began, may be understood and appreciated by people who have had neither time nor inclination to devote their lives to the study of engineering. Few such have even the remotest conception of its magnitude. The taxpayers and residents of New York simply declared that they must have water at any price. The old aqueduct, with a daily capacity of 75,000,000 gallons, was so taxed when called on to deliver 95,000,000 gallons under pressure, that it was momentarily in danger of going to pieces. Leaks were sprung every day, and a large force of masons was kept constantly at work on repairs. A break meant a water famine in New York. How near such a horror the city was, its inhabitants may never know. Only the most diligent watching averted it. The Bronx River pipe line came to the old aqueduct's relief, but its 20,000,000 gallons disappeared as rapidly as rain in the great desert, and the people clamored for more. The total supply of 115,000,000 gallons a day failed to rinse the faucets on the second floor oftener than twice in the twenty-four hours. The public fountains thirsted in vain, and at last, losing all hope, cracked their parched basins into geometrical shapes, like mud on a river's bank in time of drouth. The streets could not be sprinkled because there was no water to spare, and the eyes of all the people were blinded with dust.

A new water supply was talked of for several years, and numerous plans were suggested. Finally a new Croton aqueduct was decided on. The spillway at Croton Lake was wasting daily millions of gallons which the old aqueduct could not bring to the city. This water must be saved.

UP SHAFT NO. 4 IN A BUCKET.

But to return to the tour. Between shafts No. 2 and 3 the tunnel is 540 ft. under ground. Shaft No. 2 is 349 ft. deep, and No. 4, 350 ft. The tunnel changes not a whit as the miles are scored. It is decided to make an exit at No. 4, and to resume the journey on the morrow. At the bottom of the shaft there is a platform above the water, with a dozen barrels of cement around the edges and a pile of bricks on one corner. In the center sits an iron bucket as big as a hogshead, and a wire rope an inch thick is fastened in the looped handle. This rope leads the eye up the shaft a distance of 246½ ft., where it seems to go through a hole about the size of a silver dollar. The lower end of the shaft, about thirty feet of it, is spread out flat, like a whisky flask, but all the rest, 216 ft., is round, the whole resembling a bottle with a very long neck, such a neck as the Kentuckians like when they "liquor up." There is an iron ladder fastened to the lining from top to bottom, but the rungs are greasy with moisture, and an ascension by means of them is not inviting. A climb of 246½ ft. up a perpendicular ladder, even when it is dry, is not a diversion that appeals to the tunnel tourist. The bucket has many advantages.

Mr. Rice gets in first, then the reporter clambers in, followed by Mr. Gowen. The bucket is waist deep. An inspector who has been waiting on the platform, climbs upon the rim and stays there all the way up, holding to the rope with one hand, while with the other against the rudder he keeps the bucket from swaying or turning.

"We want to go slow," said Mr. Gowen, as he takes in his candles.

The inspector jerks the signal rope four times, the rope becomes taut in an instant, and the bucket begins to rise. After passing the flask and getting well into the neck of the bottle, the draught becomes so strong that coat tails fly up and hats have to be held on with both hands. As the silver dollar at the top draws near, it gradually expands, till it looks as large as a cart wheel. The bucket stops, with its rim on a level with the copestone, and the inspector steps off, followed by Mr. Gowen. Without waiting for instructions, the reporter proceeds to do likewise. Pulling himself up by the rope, he manages to get both feet on the rim. Then, reaching out his right foot, he plants it on the copestone, placing himself in the attitude of the Colossus at Rhodes. The bucket sways to the opposite side of the shaft and turns slightly, opening a gap as black as the bottomless pit. When it sways back to its proper place, the reporter throws his weight on his right foot, gives a quick push with his left, and is safe on the copestone. Mr. Gowen heaves a sigh of relief.

"It's all right now that you're safe," he says, "but that isn't orthodox."

He then explains that the orthodox way of leaving a bucket at the mouth of a shaft is to begin by taking firm hold of a knotted rope fastened to a stanchion for the purpose, and never to let go of it till safely landed; for, without such precautions, a misstep, a slipping of the foot, a tilting of the bucket, would mean certain death.

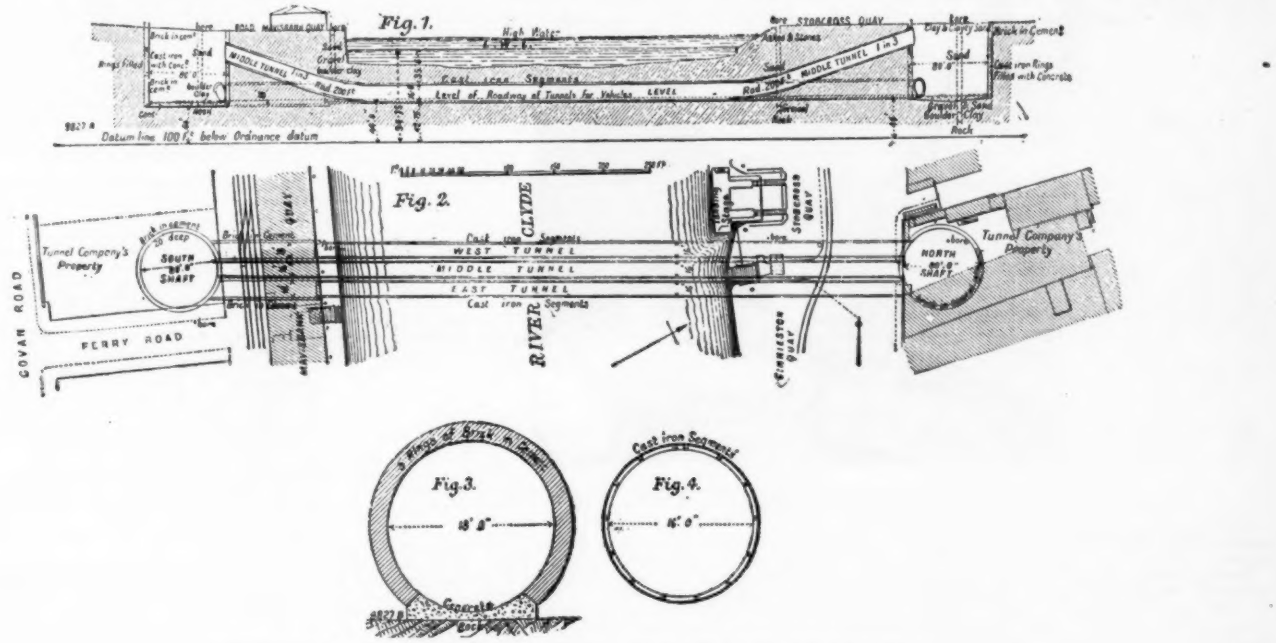
The open air is frosty, but, before it strikes to the marrow, the tourists, buttoning their rubbers tightly, start off on a run for the office, which is not more than a half a mile away. There they find "Jim," the faithful hostler-janitor, who has brought their clothes over from the lake, and into these they jump in short order. Ten minutes later they find "Jim" in the dining room, where a royal dinner is waiting to be attacked. And it is attacked. No quarter is given. For a time it seems as if the spoons and forks are in danger.

"How many eggs have I eaten, Jim?" Mr. Rice inquires.

"Nine, sir," Jim replies, with the promptness of one who has been keeping count. And yet the eggs are only a small part of the dinner. A tunnel tour for an appetite! There's nothing like it.

It is now 5 o'clock. A drive to Sing Sing and a ride to New York on the express end the first day. In town the reporter finds himself uncomfortable on the sidewalks. His legs fail to understand him properly. They want an incline or a stepoff. The left seems to be about six inches shorter than the right, so in order to humor this feeling he walks around with his right foot in the gutter and his left on the curbstone. This harmonizes everything.

(*To be continued.*)



TUNNEL UNDER THE RIVER CLYDE, AT GLASGOW.

TUNNEL UNDER THE RIVER CLYDE AT GLASGOW.

IN the last session of parliament power was granted to a private company to construct a tunnel under the River Clyde, at Glasgow, to provide what has for many years been desiderated by the citizens—a means of taking vehicles across the river between the north and south parts of the central part of industrial Glasgow. The contract for making the tunnel has now been let to Messrs. Hugh Kennedy & Sons, Partick.

The river tunnel is to be situated at Finnieston, about the middle of the harbor.

The plan proposed by Messrs. Simpson & Wilson, C.E., Glasgow, and adopted by parliament, has many points of advantage, and is described in *Engineering* as follows:

With three tunnels the vehicular traffic going south will have a separate subterranean passage, and there will also be one for the traffic going north, while the central tunnel is for passengers only. There will be only 2 ft. between the tunnels. The diameter of the part of the tunnel under the river built in cast iron segments will be 16 ft., and that under the quays, where there is bowlder clay, will be built of brick arching, and be 18 ft. in diameter. At their highest points the tunnels are to be 15 ft. below the bed of the river, thus leaving ample room for future dredging operations, and 35 ft. and 46 ft. respectively below low and high water levels. The shaft on the north side will be about 400 ft. west of Finnieston street, and 180 ft. from the quay wall, while the shaft on the south side adjoins the Govan road, and is about 125 ft. from the quay wall. As the river is 415 ft. wide, the length of tunnel from shaft to shaft is 720 ft.

Both shafts will be round and 80 ft. in diameter. The shaft on the north side of the river will be 72 ft. 6 in. deep, and that on the south side is 75 ft. 6 in. deep.

The shaft is to be formed of an outer and inner ring of cast iron segments or plates measuring 4 ft. long by 2 ft., and of ½ in. metal with 3 in. flanges bolted together. The surface having been made perfectly level, the two rings forming the first segment will be placed in position, and the 4 ft. between the rings filled with concrete. To the bottom of the segment will be fitted a cutting edge of ▽ section.

The excavation of the material occupying the space inside the segment will cause it, of its own weight, to sink, and segments will be added as the cylinder sinks down. When this cylinder reaches a depth of 27 ft., the bolting on of additional segments will be discontinued; but the cylinder will still be sunk until the bowlder clay is reached—at a depth of 45 ft. From the top of the cylinder, when in its final position, to the surface level—18 ft.—the wall of the shaft is to be ordinary brickwork in cement, while the bottom part of the shaft is also to be walled with brick, as there the bowlder clay does not require the cast iron segments. At its final depth of 75 ft. the walls will have rock for their foundation, and the flooring will be of concrete.

The shaft on the south side having been completed in the manner described, the tunneling will be started in a northern direction. For a distance of at least 100 ft. the material is bowlder clay, with the Mavisbank Quay on the surface. This part will be constructed on a concrete invert flooring, with circular brick lining 2 ft. thick (five rings), the diameter being 18 ft. The remaining part of the tunneling is of iron segments 1 in. thick, measuring 4 ft. long and 18 in. broad, with flanges 1½ in. by 6 in. deep, strengthened by stiffeners 12 in. apart. Between the segments there is a space, ⅜ in., for wedging up with soft wood, so as to make it water tight. This system of wedging up iron segments has been largely adopted in the north of England under great pressures, sometimes as much as 200 lb. to the square inch. In the case of the Clyde tunnel the pressure is not expected to be more than 25 lb. to the square inch.

The shaft on the Finnieston (the north) side of the river will be founded 80 ft. below the surface level. Cast iron segments similar in construction will be sunk the whole depth, but for 18 ft. above the segments the

wall of the shaft is formed of brickwork. The foundation of the shaft is to be composed of concrete 8 ft. thick in the center and thinning to 4 ft. at the sides.

The segments on the inside of each shaft will have their flanges turned inward except where the tunnels are intended to enter the shaft. At these points the flanges are turned outward in the case of the inner ring of the segments, so that the bolts will be exposed and the segments easily removed for the bolting of the tunnel to the side of the shaft. When this is being done, a cast iron round air tight cover will be bolted over the place where the junction is to be made. This will allow the connection to be made under air pressure, which is necessary, as the material is wet sand. The round cover can only be removed when the connection is finished and bolted.

The center tunnel, which is for passenger traffic only, is to be formed of iron segments from shaft to shaft. The gradients of 1 in 3 at the end will have flat stairs, and from the landing, which will take up the inner half of each shaft, there will be stairs to the street level, thus obviating the necessity for hoists, against which there seems a prejudice in the public mind.

The outer half of each shaft is to be fitted with six hydraulic hoists for vehicles. The two center hoists are to take 10 tons each, and will be worked on the balanced principle. Of the other four lifts, two will be capable of raising 7 tons each, and the other two 5 tons each. These will be worked independently of each other. The hoists on one side will be used in connection with the tunnel for traffic going northward, and the other two for the southward traffic. In this way the possibilities of the hoist not being in position for use when required are reduced to a minimum.

EXPERIMENT IN MAGNETIZATION.

TAKE a pocket or table knife and lay its blade flat upon the back of a fire shovel, as shown in the figure. With a pair of tongs held firmly in the hand rub the blade vigorously, and always in the same direction from point to base. Turn the blade over now and then, so that the friction may be applied to both sides. After a rubbing of from forty to fifty seconds, the blade will be magnetized and be capable of lifting a needle with which it is placed in contact, point to point.

EXPERIMENT IN MAGNETIZATION.

The magnetization will last a long time. This experiment, which is not put down in works on physics, is very interesting and worthy of study. We have found that the point of a knife magnetized in this way constitutes the north pole.—*La Nature.*

ELECTRICITY IN THE DWELLING.*

By E. PERCIVAL ALLAM.

IN this short paper it is not proposed that the time should be taken up with the history of the subject, but, assuming that in these days every one is acquainted with at least the salient features in the development of electrical science, it will at once proceed to the consideration of, first, the chemical battery, and some of the apparatus worked by its aid; then, touching lightly on the theory of electro magnetism, and the production of electric currents by induction, pass on to examine the construction of telephones and dynamos; and, lastly, explore the ever-widening field of the electric light and its vigorous offspring, electric power supply.

At the outset, then, let us consider primary batteries, as one of the means for producing the electric flow or current. By this appliance electricity is produced through the oxidization of some metal, generally zinc. Thus the battery is somewhat analogous to the boiler of the steam engine. Owing, however, to the great cost of zinc as compared with coal, the steam engine is a vastly more economical producer of power than the battery.

In the ordinary bichromate of potash cell a zinc plate is submerged in sulphuric acid, together with a non-oxidizable conductor, such as carbon. Owing to the chemical action produced by the acid, a difference of potential is produced between the carbon and zinc, the result being that a current flows on the two being connected together by some conducting material. The bichromate of potash is used to "kill" the hydrogen bubbles which form on the carbon plate.

For intermittent currents a different type of cell is generally used. It is termed the Leclanche cell, and has the zinc standing in a solution of sal-ammoniac, while the carbon is surrounded with powdered manganese dioxide and carbon.

The currents obtained by these batteries are far too small for use in lighting, except where only one or two very small candle-power lamps are required; their chief use is for working telephones and for ringing electric bells.

In these bells the current is caused to traverse several times round a soft iron bar, thus making it, for the time, a magnet. A pivoted "keeper" is attracted, and causes the hammer attached to it to strike the bell or gong. This breaks the circuit, the magnetism ceases, and the hammer flies back again, completing the circuit, and again causing the hammer to strike, and so a succession of strikes is maintained as long as the bell is kept in circuit.

Several designs of these bells may be seen on the table, one, called the "continuous action bell," being so arranged that on being started by some one closing the circuit, it will continue to ring until some one at the other end pulls down the lever at the side. This is particularly suitable for use in servants' rooms and other similar places. A different type of bell, and one coming now into considerable use, is the "magnetic bell." In this the battery is dispensed with, the current being produced by what is in reality a small dynamo. The action of this will be considered when dealing with the theory of dynamos and motors.

On the table will be found various pushes, used for completing the circuit, burglar alarms, which upon any attempt to force open a door or window set an electric bell ringing, and a neat appliance to act as a fire alarm. In this apparatus we have a thermometer, into each end of which is fixed a platinum wire, the bottom wire being in connection with the mercury. In the normal state there is no connection between the wires; but with an increase of temperature, the mercury rises in consequence of its expansion, and touching the top wire, completes the circuit and rings the alarm bell. Other fire alarms are composed of two plates of different metals soldered together, and fixed at one end. Owing to the different rates of expansion of the two metals, the plate becomes curved on being heated, and thus, by a suitable arrangement of contacts, rings the alarm.

The telemeter is an ingenious American device for automatically registering the temperature of any place. This instrument comprises two parts—one, called the transmitter, consists of a metal thermometer; the other, the registering instrument (which may be at any distance from the transmitter), comprises a clock revolving a circular card, divided into hours and days. At certain intervals a current is sent from the transmitter, and the position of the thermometer there is recorded on the dial. At the freezing chambers in Leadenhall Market, where it is most important that the temperature should not fall below a certain point, these instruments have been used most successfully.

We now come to the most important part of our subject, viz., the application of the currents produced by electrical induction. In the year 1830 Faraday made the discovery that if a pole of a permanent magnet is moved in or out of a coil of wire, currents are produced in the coil while the motion of the magnet lasts. To understand this phenomenon and the theory of dynamos, we must make a rather minute investigation into the electrical relation between a permanent magnet and a closed conductor in motion.

We must first of all remember that every magnet is surrounded by what are called, for want of a better name, "lines of magnetic force." These lines run from one pole of the magnet to the other through the surrounding air in curves.

This can be made manifest by the well-known experiment of placing a sheet of paper over a magnet and dusting over it fine iron filings, the filings being then found to arrange themselves in curves corresponding to the invisible lines of force. By a similar use of these filings it can be shown that every wire ring through which a current is flowing is also surrounded by these lines, only in this case they form whirls round the wire. Now if we consider the wire wound into a spiral of many turns, it can be easily seen that the magnetic whirl of one turn will interfere with the whirl of the neighboring ring, and the result will be that instead of each coil having a wrapping of the lines, they will run continuously through the whole spiral, completing the magnetic circuit in curves through the surrounding air, exactly as in the case of the permanent magnet. If a piece of soft iron be now inserted in the spiral, the lines of force will run through it, making it for the time an "electro-magnet," identical in every respect with iron containing permanent magnetism.

Having now a clear idea of what we mean by "electro-magnetism," we can the better appreciate the importance of the discovery previously alluded to. Faraday found that when a pole of a magnet was moved into a closed coil, so that more and more lines of force from the magnet were threading themselves through the coil, a current would be produced in one direction, and on withdrawing the magnet, and thus decreasing the lines of force through the coil, a current would again be produced, but in an opposite direction. He also found that the more quickly he moved the magnet, the more current he obtained in the wire, and that if he held the magnet still, no matter in what position with regard to the coil, no current would be produced.

By many similar experiments he concluded that a current could be produced in a closed circuit, whether by the circuit being moved near the poles of the magnet or by the poles being moved near the circuit, as long as the number of lines of force were either increasing or decreasing.

Although Faraday knew full well the value of these experiments, it was left to others to put these results to practical use, the outcome of which is the modern "dynamo," the most efficient of all transformers of energy, giving out in the case of the most perfect machines more than 90 electrical horse power to every 100 horse power put into it.

In this machine we have a large electro-magnet, near the poles of which the coils of wire rotate, cutting the lines of force and generating a current. A part of this current passes round the magnet, and keeps up the proper number of magnetic lines across the poles. The remainder of the current is available for use, either for lighting lamps or driving motors.

In order that the current may always go the same way, and not alternate as in the experiments of Faraday, it is led, before leaving the machine, to a rotating arrangement of copper segments, called a "commutator," each coil of the armature having a segment of its own. Two brushes press against this and collect the current. When one segment passes a brush, the current is flowing in one direction, but at the half turn, when it passes the second brush, the current flowing in it has reversed. On again passing the first brush the current has again changed, and flows through it in the same way as before. Thus a continuous flow of current is maintained from the generator.

Before passing on to the uses made of the current thus generated, let us turn aside for a few moments and consider the telephone. This instrument belongs to the position here assigned to it, for it is in reality a small dynamo, the voice, when speaking into a transmitter, producing vibrations of an iron plate in front of a magnet; thus by cutting the lines of force variable currents are sent along the line wire, producing similar vibrations of the iron disk in the receiver at the other end, and so reproducing the sounds.

The telephone exchange system, by means of which persons at a considerable distance apart are at once put in communication with each other, is familiar to all; but the telephone is essentially a domestic instrument, and it would no doubt be far more used as such, were it not for the shortsighted policy of the owners of the original patents, with their all but prohibitory tariffs.

There are, however, now several cheap and good telephones not covered by these patent rights, which are most useful on short lines of not more than a mile or so in length. Such telephones are well adapted for forming a connection between the office and the factory, the residence and the stables, or in connecting the distant parts of large buildings, replacing the somewhat costly speaking tube with advantage, as the small wires can be easily fixed, even after a house is built and finished, so as to be quite unseen—an impossibility with the clumsy-looking tube.

Returning to the main subject we have in hand, the application of electricity for lighting next engages our attention. For public and street lighting the large arc lamps are almost exclusively used. These consist in their essence of two carbon rods placed opposite each other, with a mechanism for keeping the distance between the points always the same. The current on entering one of these lamps flows through the magnet and through both carbons. By this means the carbons are separated, and the points become very hot, owing to the resistance that the air space offers to the current.

So intense is the heat thus generated that portions of the carbon are volatilized, and small particles are constantly detached, forming in the intervening space an arc of white hot carbon dust of the most intense brilliancy and of an extremely high temperature. It is the office of the magnet and mechanism connected with it to bring the carbons together in proportion as they wear away.

As the light produced by this means cannot remain perfectly steady for any length of time even in the best made lamps, owing to the impurities always present in the carbons, which so far have baffled every attempt to eliminate them, it is not suitable for small buildings or private dwellings—its chief use being for our larger public buildings and for open spaces. For the dwelling house, however, we have an admirable means of lighting in the "incandescent" or "glow" lamps. These well-known lamps consist of globes carefully exhausted of air and containing a fine thread-like loop of carbon, which glows with a brilliant white light on the passage of the current. By means of these little lamps the most artistic effects can be produced—effects which delight the eye, for here we have light without glare. Although the glowing filament is at a white heat, yet owing to its small bulk the heat given off by the lamps is not appreciable.

Thus they may be placed close to the walls or decorations of a room, if desired. They are, indeed, under the most perfect control, and by suitably arranging them we can, if we please, have light without any visible source, which is the ideal method in the science of illumination.

The brilliancy of the carbon filament can be subdued, if desired, by obscuring the glass globe by roughening its surface by means of the sand blast, but the more general way is to surround the globes with shades of various shapes and colors. These are familiar to all. Most of the lamps in use have a nominal candle power of sixteen, but in places where a more brilliant light is wanted, thirty-two or fifty candle-power lamps may be used.

On staircases and in passages, where the light is required but occasionally, eight candle-power lamps are sufficient, and economize the current.

It is impossible to give a reliable rule as to the number of lamps required to light any given area, on account of the varying amounts of light absorbed by different colored surfaces. The only good method, where practical, is to take several good oil lamps and place them round the room until the desired effect is obtained. The position of these will then mark where

* A paper read at a meeting of the Society of Architects, London, January 28, 1890.

the glow lamps ought to be fixed when the house is being wired.

In lighting by gas, to avoid complications of pipes in walls and ceilings, it is the common practice to group the gas jets together as much as possible. It is best, however, to distribute the light as much as possible, and the most pleasant lighting is obtained when the glow lamps are placed around the room about three feet from the walls, and from seven to ten feet from the floor.

Nowadays, is is unnecessary to speak of the many advantages of the electric light over its rival—gas. One may, however, mention the lessened danger from fire, the absence of heat, the whiter light, and the freedom from all the noxious vapors which are produced by coal gas, to the destruction of books and pictures and harm of animal and vegetable life.

When the lamp is to hang from the ceiling, the current is brought down the wires which support the lamp and shade. These insulated twin wires are twisted together and covered on the outside with silk to any suitable pattern, and form a pleasing contrast to the inartistic gas pipe. If the drop be a long one, the line of straight wire is generally relieved in the middle by glass beads or ornamental metal sprays, etc., threaded on. When brackets are used, care should be taken to avoid making them look like adapted gas brackets. Artistic forms in wrought iron and hammered brass and copper are readily designed for the purpose, so as to harmonize with the style of decoration and furnishing of the room.

When a house has its own generating plant, the engine and dynamo are usually placed in the basement, or in a separate building outside. The cable is brought from thence to a switch board, on which is placed a main switch for breaking the whole current, if desired, an ammeter and voltmeter for measuring the current, and an automatic cut-out for breaking the circuit should there be an excessive flow of current through any accidental cause, such as two naked wires coming accidentally into contact. From this board wires branch off to the various rooms.

When houses in course of construction are wired for the light, the wood casing containing the cable and wire is fixed to the naked brick walls, and hidden from sight by the subsequent coatings of plaster. This, of course, makes very neat work, and if the house is a fairly dry one, the buried wires well insulated with pure India rubber, and the work properly done, there is little likelihood of anything going wrong. At present, however, the task usually presented to the electrical engineer is to run the wires in a house, not only finished and decorated, but furnished. Then the casing has of necessity to be fixed to the wall, and is apt, if due care is not taken, to spoil the decoration and appearance of the room, besides producing the usual damage in cutting away for inserting the wooden plugs.

In order to minimize this disfigurement as much as possible, Messrs. Nicholson & Jennings have recently introduced a new kind of casing made of a material resembling Lincrusta Walton. This material can be moulded to any design, and colored to suit the intended surroundings, while the cost is not more than the ordinary wood casing.

When the wires have to run across the ceiling this might be used with advantage, dummy lengths being run at right angles to form panels.

Split bamboo canes have been lately suggested for use in covering the wires. These would no doubt look extremely well if polished, and would match the Japanese furniture and decorations now found in so many houses.

A better plan, however, than running the casing on the ceiling is to lay it under the floor of the room above, across the joists, bringing the wires down through the ceiling.

In most cases, wires from the lamps are brought down the walls to what are termed switches; these control the current for any given lamp or lamps, and take the place of the gas tap. Sometimes, however, the switch is placed in the holder, just above the lamp. The switches are generally made with a slate or china base, with a metal, wood, or china cover.

The arrangement of the mechanism inside varies with every maker, but the object is in each case the same, to break and close the circuit by the movement of a handle or lever, care being taken that good contact is made between the metal parts conveying the current when the switch is "on," and that there is a good spring keeping the switch always "off" until moved by hand into the reverse position.

A "wall socket" is a handy arrangement for obtaining a light that may be shifted to different parts of a room. At any convenient point on the wall a socket is fixed to which the wires for the mains are led. When a light is required in the movable lamp, all that has to be done is to connect it with the socket by means of a flexible wire cord, with a plug at one end. By having several of these sockets placed in various parts of the room, the electric lamp may be made as portable as the common oil table lamp.

The householder, on the introduction of the electric light, is apt to imagine that, having got rid of his gas pipes, he need no longer dread the possibility of fire. However, when one considers the intense heat generated in the electric arc, and the fact that the glowing of the filament in incandescent lamps is also the result of heat, it is obvious that the element we have to deal with is by no means of an inoffensive and harmless nature, and that immunity from fire can only be obtained by adhering to the required conditions, by exercising great care in the perfect insulation and protection of the conductors.

Much of the care displayed in England by the electrical engineer has been due to the stringent rules drawn up by the fire offices, and which have to be strictly adhered to by the contractor in order that the work may be passed by the company's inspector. The rules published by the Phœnix Fire Office, under the direction of Mr. Musgrave Heaphy, are those most generally used.

These rules deal with the details that have to be observed by the contractor, such as the proper insulation of the wires and cables, the distance at which the wires must be laid from one another, and the introduction of a proper number of fuses in the circuit.

Some of these rules may appear unnecessary and to show an amount of over-carefulness, but in a matter like this it is better to lean to the side of over-carefulness; and I think that these rules have greatly helped to increase the adoption of the electric light by inspiring the public mind with confidence in its perfect safety as well as its many other advantages—for by adhering to these rules electric lighting may, beyond doubt, be made absolutely safe.

The Phœnix Fire Office, in the preface to its rules, remarks:

"The electric light is the safest of all illuminants, and is preferable to any other, when the installation has been thoroughly well put up."

This paper would not be complete without a short description of the various systems now in practical use for the distribution of electricity from central stations. The first and oldest method is to employ continuous currents at a low pressure. This can only be done when the supply station has its customers all within a small radius, for as the cross-sectional area of the main cable has to be increased in proportion to the current, a very large amount of copper has to be used when the current is great, thus making the cost of the mains a very heavy item when the district served is a large and straggling one.

To avoid the use of these expensive mains a new system has been brought into use during the last few years, and has been almost universally adopted where the lights are scattered over a large area. This is known as the "Transformer System."

The dynamos employed are designed to give currents of a very small quantity but of high pressure. They, moreover, instead of being continuous as in the low pressure system, alternate very quickly in their direction. The currents thus generated do not flow through the lamps, but through a piece of apparatus called a "transformer," which is placed in the dwelling to be lighted. This transformer works on the principle of the medical induction coil. The high pressure current traverses a number of coils of fine wire. Over these coils are wound a smaller number of turns of coarser wire, the ends of which are connected to the lamps. Owing to the current in the fine coil alternating, varying lines of magnetic force are formed which cut the coarse coil, producing alternating currents in the lamp circuit.

This "secondary" current, however, is of a large quantity and at a low pressure. The main cables used in this system are of small size, and can be laid down at a moderate cost; great care, however, has to be taken that the insulation is kept perfect, otherwise great loss is sustained by the current leaking to the earth, and there is the risk of workmen who may accidentally touch the defective cable receiving dangerous shocks.

The third method to be mentioned is also on the converter principle, in which a small high pressure current is transformed into a low pressure current of greater quantity.

In each house or sub-station a battery of accumulators is placed, and the high tension continuous current from the central station has to pass through each set of the batteries in any given district. The secondary current from each sub-station is taken from its own battery.

Thus, if there are ten sub-stations and batteries in any district, the pressure on each secondary circuit will be but one-tenth of the pressure of the current supplied from the central station.

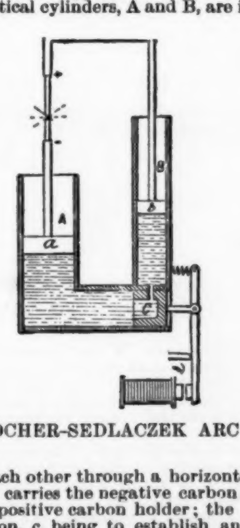
As the authorities have forbidden electric light wires to be run overhead, every company has now to lay its mains underground. Several systems are in use, the chief aim being in each case to keep the two cables well insulated from each other and from the earth, and protected from accidental blows of picks and shovels. Sometimes the cables are well insulated with India rubber, sheathed with lead, and then placed in earthenware or wooden pipes filled with creosote and pitch. Another plan is to place the naked copper in brick conduits or iron troughs, simply insulating it by running it on earthenware or porcelain insulators.

In concluding this paper the author must apologize for the superficial manner in which he has treated the subject, but the time at his disposal was short, and he has had to cover a considerable extent of ground in describing the ever-growing number of uses to which we have learned to put that most subtile and mysterious form of energy called electricity.

THE STOCHER-SEDLACZEK ARC LAMP.

THE principle of the Stocher-Sedlaczek arc lamp is the same as that of MM. Lacassagne and Thiers; but the liquid employed is glycerine instead of mercury. In the accompanying figure we have a diagrammatical representation of the apparatus.

The two vertical cylinders, A and B, are in communi-



THE STOCHER-SEDLACZEK ARC LAMP.

cation with each other through a horizontal cylinder. The piston, *a*, carries the negative carbon holder, the piston, *b*, the positive carbon holder; the function of the third piston, *c*, being to establish and interrupt communication between the cylinders, A and B. An electro-magnet placed in the main circuit, by influencing an armature connected to the piston, *c*, actuates the latter. When the action of the electro-magnet weakens, a spring causes the armature, and consequently the piston, *c*, to move in the reverse direction.

On the circuit being closed, the armature is attracted and the piston, *c*, moves from left to right, cutting off communication between A and B, and causing piston, *a*, to fall and strike the arc. When the current weakens by reason of the lengthening of the arc, the spring overcomes the attraction of the electro-magnet upon its armature, and the piston, *c*, is moved from right to left, communication between the two vertical cylinders is restored, liquid flows in from B to A, and the arc is reduced to its normal dimensions. The diameters of the cylinders, A and B, are proportioned so as to give the arc a fixed position. This lamp can be employed with advantage on locomotives, the light remaining very steady even when exposed to severe oscillation.—*Fontaine's Eclairage a l'Electricite, in The Electrician.*

AN ELECTRICAL CONTACT THERMOMETER.

UP to the present, an adjustable thermometer alarm with a sealed mercury column has been a great desideratum. There is an adjustable *open-tube* thermometer, which is, however, not very accurate. And there is a closed tube thermometer with immovable platinum points (fused in the glass), which is, of course, only serviceable for the particular temperature it is made for.

M. Stuhl, of Berlin, has now overcome the difficulty and constructed an adjustable closed-tube thermometer, which is here described.

Below the beginning of the scale of the thermometer there is a small resistance, in the shape of a knob of glass, fused into the bore of the thermometer tube (see C in Fig. 1, and the enlarged view in Fig. 2). This

FIG. 1. FIG. 2.

LAUTENSCHLAEGER'S ELECTRICAL CONTACT THERMOMETER.

knob leaves a fine capillary passage for the mercury upward when it expands by heating, but causes the mercurial column to break at the contraction upon cooling, so that all the mercury above the knob will be retained there, while that below the contracted place will separate and contract into the bulb, on the same principle as is carried out in the registering clinical thermometers. Immediately below the knob, a platinum wire (forming one of the electric poles) is fused into the glass. The other wire (or pole) is fused into the bulb, and is constantly in contact with mercury.

When the thermometer is to be set for a particular temperature—assuming that the mercurial column is continuous, or has been rendered so by shaking the mercury down—it is heated in any convenient manner until the exact point on the scale (say for instance 40° C. = 104° F.) has been reached by the mercury. It is then removed from the source of heat and allowed to cool.

As it begins to cool, the mercurial thread will be ruptured at the contracted place, and the mercury below will shrink into the bulb, while the mercurial column above the knob will also shrink proportionately. If now the thermometer is heated again until the mercury above the knob again stands at 40° C., the mercury in the bulb will also again expand so as to reach the upper column terminating at the knob. Just before reaching it, it will pass and touch the wire entering at B. If the wires are connected with a battery with interposed electric bell, the latter will immediately ring. When the temperature falls, the mercurial thread will break again as before and the alarm cease. The distance between the contracted place and the entrance of the wire, B, is so small that it has no influence (or scarcely any) upon the exact temperature. When a different temperature is to be fixed upon, the mercurial column is reunited by shaking or swinging, and adjusted, as above described, to the new place on the scale.

BLUE, VIOLET, RED, AND GREEN PRINTS.

FROM the book by E. M. Estabrooke on "Photography in the Studio and in the Field," we extract the following practical formulas:

BLUE PRINTS.

Float the paper until it lies quite flat upon a solution prepared as follows:

1.	Water	2 ounces fluid.
	Red prussiate of potash	120 grains.
2.	Water	2 ounces.
	Ammonia citrate of iron	140 grains.

When these two are dissolved, mix them together and filter into a clean bottle.

The solution should not be exposed to a strong light, and the paper must be floated on it in a very subdued light, and in the same manner as paper is floated on a silver solution. When it no longer curls, but lies flat on the solution, take it by the corners and raise it slowly from contact, and hang it up to dry in a dark place. When dry, it can be used at once, or may be kept for future use by rolling it, prepared surface in, and placing it in a tin box or other receptacle, free from light and dampness.

To make a print on this paper, place the prepared surface in contact with the negative in a printing frame and expose to sunlight.

The time of exposure will vary according to the density of the negative and the intensity of the light. The rule is to allow the light to act long enough for the portions which first turn blue to become gray, with a

slight metallic luster. At this point remove the paper from the frame and place it in a dish of clean water.

It now gradually becomes a rich blue throughout, except the parts which should remain white. Change the water from time to time, until there remains no discoloration in the whites; dry, and the picture requires no further treatment.

The blue color may be totally removed at any time by placing the print in ammonia water.

This is the standard formula.

ANOTHER PROCESS FOR BLUE PRINTS.

Float the paper for a minute in a solution of

Ferridcyanide of potash..............1 ounce.
Water....................................5 ounces.

Dry it in a dark room, and then expose beneath a negative until the dark shades have assumed a deep blue color, then immerse the print in a solution of

Water.....................................2 ounces.
Bichloride mercury.......................1 grain.

Wash the print, and then immerse it in a hot solution of

Oxalic acid.............................4 drachms.
Water.....................................4 ounces.

Wash again and dry.

ANOTHER PROCESS—THE CYANOTYPE.

Float the paper on a solution of the sesqui-chloride of iron. Dry and expose, afterward wash the prints, and then immerse them in a bath of ferridcyanide of potash. The picture will appear of a blue color in all those places where the sun has acted.

PROCESS WITH SALTS OF URANIUM.

The paper, without having undergone any preceding preparation, except that of having been excluded from the light for several days, is floated on a bath of the nitrate of uranium as follows:

Nitrate of uranium.................2 drachms.
Distilled water.....................10 drachms.

The paper is left on the bath for four or five minutes, it is then removed, hung up, and dried in the dark room. So prepared, it can be kept for a considerable time.

The exposure beneath a negative varies from one minute to several minutes in the rays of the sun, and from a quarter of an hour to an hour in diffused light. The image which is thus produced is not very distinct, but comes out in strong contrast when developed as follows:

NITRATE OF SILVER DEVELOPER.

Distilled or rain water............2 drachms.
Nitrate of silver...................7 grains.
Acetic acid.........................a mere trace.

The development is very rapid in this solution. In about half a minute it is complete. As soon as the picture appears in perfect contrast, the print is taken out and fixed by immersion in water, in which it is thoroughly washed.

CHLORIDE OF GOLD DEVELOPER.

This is a more rapid developer than the preceding. The print is fixed in like manner by water, in which it must be well washed, and afterward dried. When dried by artificial heat, the vigor of the print is increased. Prints that have been developed by the solution of nitrate of silver may be immersed in the gold bath, which improves their tone.

The picture may be developed, also, by immersing the prints in a saturated solution of bichloride of mercury and afterward in one of nitrate of silver. In this case, however, the times of exposure must be increased.

Pictures may be obtained, also, by floating the papers on a mixture of equal quantities of nitrate of silver and nitrate of uranium in about six times their weight of water.

When dry, they are exposed beneath a negative. In this case the image appears, as in the positive printing process, with chloride of silver, being effected by the decomposition of the nitrate of uranium, which, reacting on the nitrate of silver, decomposes this salt and reduces the silver. These prints require fixing in the ordinary bath of hyposulphite of soda, and then washing, as usual.

PROCESS FOR RED PICTURES.

Float the papers for four minutes in the preceding bath of nitrate of uranium, drain, and dry. Next, expose beneath a negative for eight or ten minutes, then wash, and immerse in a bath of

Ferridcyanide of potash..............30 grains.
Water....................................3 ounces.

In a few minutes the picture will appear of a red color, which is fixed by washing thoroughly in water.

PROCESS FOR GREEN PICTURES.

Immerse the red picture, before it is dry, in a solution of

Sesqui-chloride of iron..............30 grains.
Distilled water.........................3 ounces.

The tone will soon change to green; fix in water, wash, and dry before the fire.

PROCESS FOR VIOLET PICTURES.

Float the paper for three or four minutes on a bath of

Water.....................................2 ounces.
Nitrate of uranium.....................2 drachms.
Chloride of gold........................2 grains.

Afterward take them out and dry. An exposure of ten or fifteen minutes will cause the necessary reduction; the picture has a beautiful violet color consisting of metallic gold. Wash and dry.

INFLUENCE OF THE PROCESS OF COOLING UPON THE OPTICAL PROPERTIES OF GLASS AND THE PRODUCTION OF PRESSED LENSES IN A THOROUGHLY ANNEALED STATE.

[A communication from the Glastechnisches Laboratorium of Schott & Gen. in Jena.]

THE very imperfect state of annealing generally met with in the glass disks for large telescopes formed for many years past a constant source of complaint of such opticians who in the manufacture of large sized lenses are working strictly spherical surfaces. For this and other reasons it has been our aim ever since the erection of our works to improve on the process of annealing. The method hitherto in use, viz., that of allowing the temperature of the red hot glass to fall in a kiln completely inclosed by brick work, which gradually transmits the heat stored up in it to the surrounding atmosphere, has been discontinued by us in all such cases where high optical properties are aimed at, and in its place we adopted the plan of storing the glass in a vessel, the temperature of which may be accurately measured and subjected to a very slow and strictly uniform decrease, the duration of which may be adjusted to suit special requirements.

FIG. 1.

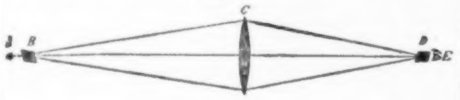


FIG. 2.

A. Illuminating source (bright-burning petroleum flame). B. Polarizing Nicol prism. C. Lens or disk to be tested. D. Analyzing prism. E. The observer's eye. S. Concave mirror.
In Fig. 1, A and E are conjugate points with respect to the lens, C; in Fig. 2, both points are situated in the plane of the center of curvature of the mirror, S.

The experimental researches which formed the necessary predecessors of our new process of annealing offered ample opportunity for minutely studying the influence of internal strains and pressures upon the optical properties of the glass. We intend to treat *in extenso* on this subject at a later date; here it may suffice to mention the most important of those results which will interest practical opticians.

(1) Any kind of glass becomes strained, *i. e.*, the molecules of the glass are subject to tension, unless the process of solidification be extended over a very long period.

(2) The refractive index of one and the same piece of glass varies according to the duration of the process of annealing; this diversity may extend to several units of the third decimal place.

(3) If a lens or circular disk on being carefully examined by means of polarized light be found to yield a regular black cross, which remains perfectly free from any distortion during a complete rotation of the disk about the optic axis, it may be inferred that the tension is strictly regular throughout the entire piece of glass under examination. The presence of a moderate tension of this kind has no other effect as if there were a slight gradual diminution of the refractive index in the direction of the axis. Owing to the symmetrical arrangement of the tensions round the axis, they do not exercise any detrimental influence on the image.

(4) If, however, a lens or circular disk, while being turned round its axis under examination in polarized light, show in any one or several positions a displaced black cross or any other irregular figure, the tension must be considered to be irregular. The influence of such tensions dissymmetrically grouped round the axis is identical to that of a difference of the refractive power in different parts of the lens. Glasses of this kind should never be employed for the manufacture of large sized objectives. With telescopic lenses made of glass where this defect existed in a moderate degree, many opticians attempt to compensate this differentiation of refraction by introducing at random deviations from strictly spherical surfaces through polishing, with the result of thus obtaining pretty satisfactory images.

By means of our method of annealing we have succeeded in producing disks for object lenses having a diameter up to 35 cm. nearly perfectly free from tension, the entire surface of the disk being made to become efficient under the polariscope. All that is necessary during the test is to exclude any differences of temperature of the disks, as these are apt to give rise to temporary tensions. Nearly all disks annealed according to the older system show the distinct black crosses characterizing the presence of strain and pressure, even in those cases where the diameter of the disk does not exceed 12 cm.

Though it must be admitted that many opticians, before grinding large sized lenses for telescopes, will ascertain the properties of the glass with respect to annealing, yet we know from experience that there is considerable inclination to underrate the serious effects of tension, and that many go as far as to consider examination before or after making a lens hardly worth the trouble.

We append to these lines a sketch of an apparatus, the principle of which is due to Professor Mach, of Prag, which may be readily put up, and by means of which plane plates (Fig. 2) or positive lenses (Fig. 1) may be tested. The apparatus must be adjusted in such a manner that with parallel Nicol prisms the eye at E sees the lens or disk to be tested fully illuminated; if now the Nicol prisms be crossed, total extinction will take place with glasses having no internal tensions, whereas with imperfectly annealed glasses the well known figures indicative of tension will present themselves.

In order to examine the figures due to strain or pressure in all positions of the prism with respect of the disk of glass, it will be found advantageous to turn both prisms synchronically rather than to turn the disks themselves, as these, owing to the touch of the warm hand, may become locally heated.

In order to better distinguish the present new method of annealing from that hitherto in use (raw annealing), we have introduced the term "fine annealing" when referring to the former.

PRESSED GLASS.

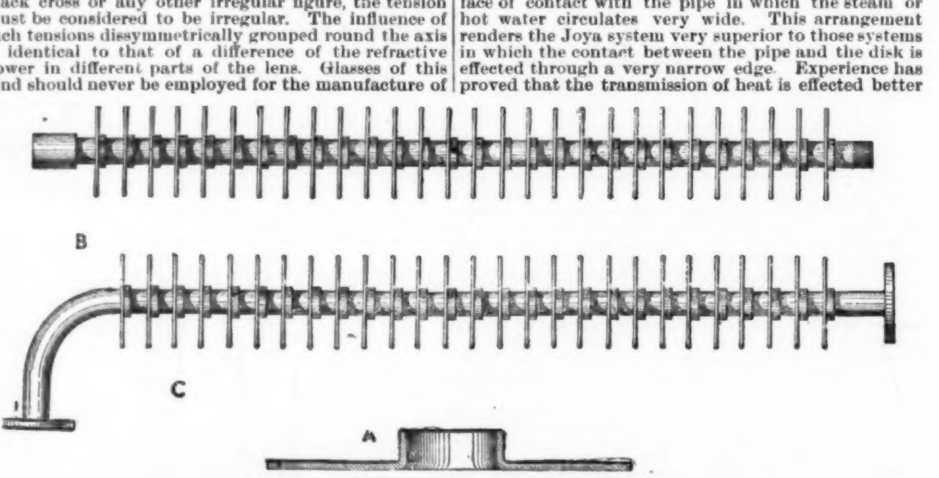
Our experiments and improvements made with regard to the process of glass annealing have induced us to adopt for our fabrication the well-known plan, worked in Paris since many years, of moulding the glass by means of pressing it while in a semi-liquid state between metal cups having as nearly as possible the same curvatures as the lens. Lenses produced in this manner are utterly useless for the application in better class instruments, if the ordinary quick process of annealing be employed, as the internal strain in the glass will generally be very great, and sometimes may become so excessive as to cause the rough lens to fly into small pieces as soon as an attempt is made to grind it. However, with our new method of annealing, which permits of annealing at such low temperatures as to put deformations out of the question, ready means are furnished to produce lenses of this kind entirely free from internal strains by subjecting them, after having allowed them to cool down, to a second process of annealing to the above mentioned apparatus.

Wishing to remove a prejudice held by many opticians, we will not omit to distinctly state that the pressure exerted on the glass while in a semi-liquid state is by no means the cause of internal strain or pressure; on the contrary, the only source of these must be looked for in the accelerated process of chilling, which has to be made use of in order to prevent deformation.

The favorable practical results obtained by many opticians with glass prepared in this manner encourage us to recommend its application for all such cases where large numbers of lenses of the same kind have to be made with various curvatures and diameters within the limits between 12 to 120 mm. The increased costs of glass prepared in this manner are amply compensated for by the saving of material and work. Lenses having the exact form of the desired lenses suffice as patterns. On account of the prolonged period of annealing, we require as a rule a term for delivery from six to eight weeks. We are prepared to submit sample lenses to our customers.—*Br. Jour. of Photography.*

JOYA'S SYSTEM OF HEAT RADIATORS.

MR. J. JOYA, of Grenoble, has devised a new system of heating pipes provided with radiators. Upon smooth iron pipes are shrunk steel plate disks, A, provided with a lug in the center, so as to render the surface of contact with the pipe in which the steam or hot water circulates very wide. This arrangement renders the Joya system very superior to those systems in which the contact between the pipe and the disk is effected through a very narrow edge. Experience has proved that the transmission of heat is effected better



JOYA'S SYSTEM OF HEAT RADIATORS.

through disks provided with lugs than by any other system. Cast iron pipes provided with such disks condense less than those with disks cast in a piece with them. Moreover, the wide surface of contact between the pipes and the disk prevents the latter from cutting the pipe in consequence of its having been shrunk on while hot. Finally, another peculiarity of this system is the great resistance that it offers, and that renders it applicable to heating by high pressure. The disks, in fact, increase the thickness of the pipe throughout a great portion of its length and give it great strength. Of the figures, B represents a pipe with sleeve couplings, and C a pipe with flange couplings.—*Chronique Industrielle.*

MACHINE FOR COVERING ELECTRIC CABLES WITH RUBBER.

AMONG the machines exhibited at the Paris exhibition by Mr. F. Soyer, there was one designed for covering copper wires and cables with India rubber. This machine we represent herewith in perspective and horizontal section. It consists essentially of a strong ribbed frame, provided with a driving shaft and an axle carrying a propelling device which acts in a drawing frame heated by steam at the beginning of operations. It is, as may be conceived, very simple and strong, and devoid of any delicate parts.

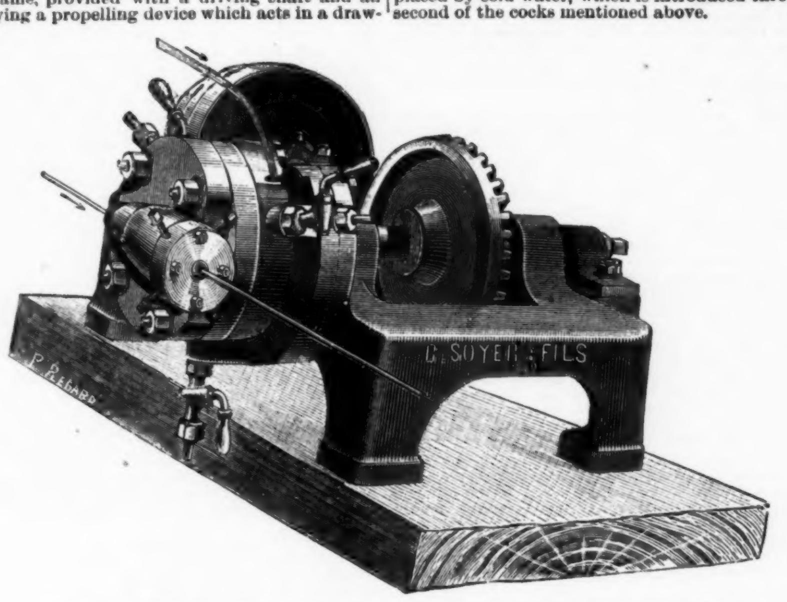


FIG. 1.—MACHINE FOR COVERING ELECTRIC WIRE WITH RUBBER.

A three-speed cone transmits a rotary motion to a shaft, which afterward acts upon the axle of the propelling mechanism through a pair of bevel wheels. The rubber is introduced progressively in a cold state into the box of the drawing frame, under the form of a band or cord, and of a section as uniform as possible. Here it is pushed continuously forward by means of the propelling device—a sort of conical screw which revolves in the box of the drawing frame, raised to a temperature of about 100° C. The propelling axle is provided with a counter point for annuling the lateral reaction that the action of the propeller engenders.

At the beginning of operations there is sent into the jacket through one of two cocks (the other remaining closed) a current of steam, the admission of which lasts until the metal of the machine reaches a temperature of about 100° C. Afterward, the rubber is introduced and operations are begun. The rubber softens under the action of the heat and is converted into a paste, and in this state is forced forward at a very high pressure by the screw, which causes it to make its exit through a very narrow aperture in front of the drawing frame.

The wire or cable to be covered reaches the center of the frame through a metallic sheath, screwed at the back to the side of the box, and held in front by a supporting screw. When the rubber begins to make its exit from the frame, care is taken to leave the copper wire at rest and not to use the forced-in rubber for a few instants. Experience has proved, in fact, that it is necessary to allow a certain quantity of rubber to pass into the frame before it can be obtained very smooth, that is, fit for use. After such a result has been obtained, the wire to be covered is started forward.

The frame, properly so called, consists of a steel block traversed by the wire and of a steel socket inserted in the plate in front of the box. On traversing this socket from right to left, the wire leaves therein an annular space that the rubber fills, so as to form a regular and continuous layer on the wire, whatever be the latter's length.

At the end of about half an hour's operations, the steam in the jacket of the drawing frame must be replaced by cold water, which is introduced through the second of the cocks mentioned above.

The work developed by the propelling device in the forcing along of the rubber is shown by the production of so intense a heat that the normal temperature of 100° for the machine would soon be exceeded, were it not for the admission of the cold water, and a portion of the rubber would be vulcanized.

Such, briefly, is the operation of this machine. Cables are often covered with rubber by means of two bands of the latter, between which the cable is interposed. Two wheels, each having a half round channel and sharp edges, afterward apply these bands of rubber against the cable, and at the same time, through their cutting edges, remove the excess of material. This process leads to an irregular manufacture. At all events, it does not form so solid a covering as the one under consideration.

In a factory for the production of electric wires and cables, the covering machine is placed in the same axis with the cabling machine. The cable therefore receives its rubber in measure as it is manufactured. If need be, another apparatus may be placed in a line with the covering machine to wind on the strip of cloth that invests most cables.

Sometimes it is desirable to double the cable covering, that is to say, to cover the cable alternately with two layers of rubber and two strips of cloth. In such case a second covering machine follows the installation above mentioned, and is followed in turn by another machine for the application of the cloth. In this way the manufacture of the cables is effected in one and the same series of successive operations.

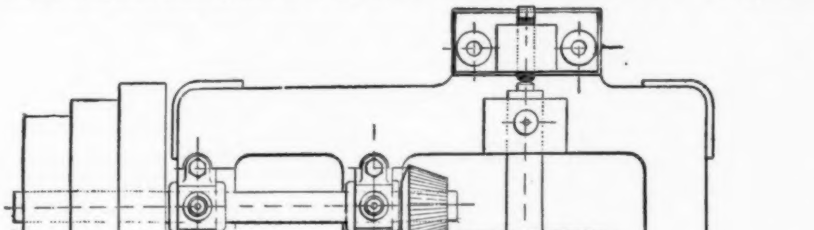


FIG. 2.—HORIZONTAL SECTION.

The machine here represented is the smallest size, and is designed for covering cables of from 10 to 12 mm. in diameter.—*Revue Industrielle.*

IN France it has been shown that frozen milk can be transported with the greatest ease, and that after being kept for days and weeks and then simply thawed out, it retains all the characteristics of fresh milk.

MASS AND MOTION.

By Prof. HENRY A. MOTT, LL.D.

THE present dynamic or mechanical theory, devised to elucidate and explain the phenomena of nature, postulates *mass* and *motion* as the absolute real and indestructible elements of all forms of physical existence.

That there can be no doubt about this, Noire, speaking of evolution, holds, with Schopenhauer, that its true source is placed in the will, *i. e.*, the subjective form of what, when it appears objectively, is called force. He holds, with Meyer and with Kant, that there is but one force of nature under different forms, itself eternal and unchangeable; and he recognizes in whatever we perceive, that is, in all that we know of nature, whether in the form of light, heat, sound, or anything else, nothing but variations of motion. That motion can be changed, but it never can be lost. "Everything," says Muller, "in nature, even organic life, is looked upon as a purely mechanical process, though it is fully admitted that science has not yet mastered the most difficult of all problems: the explanation of life as a mechanical process."

Again it is claimed (1) that the quantity of motion in the universe is a constant quantity, never being added to or diminished, and that when the visible motion of the mass disappears, it reappears as motion of the particles of the mass. 2. That a mass is set into motion only by another mass in motion; in other words, there is but a transference of motion from one mass to another.

That, of necessity, a body must possess motion in changing its position from one locality to another is self-evident, as the term "motion" is applied to express such movements; but the question naturally arises, is it correct to attribute to such phenomena (*i. e.* motion) the cause *per se* of the change in position of the body in question? It must be quite clear that although there can be no change in position unaccompanied by "motion," still, because something (a phenomenon) happens which, according to our vocabulary, is called "motion," and because some visible motion was incited by another body in motion, it does not follow that it was the motion of this latter body which caused the first body to *move* or change its position. Surely, at best, all we have a right logically to admit is that it *may be so*, but the question arises—*is it so?*

Dr. Hall, in an article published two or three years ago, referred to the crushing of a building by the fall of a tree, and clearly pointed out that it was no more the motion of the tree that crushed the building *than the motion of the shadow* on the building caused by the tree in the process of being pulled toward the earth by gravity in the sunlight.

If great velocity of motion (*per se*) could induce a body to move, certainly a quickly advancing shadow directed against a building should reduce the same to atoms.

When, however, we analyze the statements in works on physics, we find that what is really meant is *mass in motion* that is capable of doing the work of putting another "mass" in motion. It is true that such statements do not appear prominently set forth, still such is unquestionably intended to be understood.

Tyndall, for example, says: "Heat is a mode of motion." What he evidently meant to say was that: Heat is a *mode of motion of the particles of a mass.* It makes little difference what he meant, for as the distinguished savant Prof. P. G. Tait, of the University of Edinburgh, says: "Heat is no more a 'mode of motion,' than potential energy is a 'mode of rest.'"

When we look upon motion as a phenomenon, the effect of a cause, then we will be better able to explain not only what "heat" is, but what electricity, magnetism, gravity, sound, etc., are; for, as Prof Tait says: "Heat, whatever it may be, is *something* which can be transferred from one portion of matter to another."

Is motion then a phenomenon? According to the present theories of science: a body is heated to a given temperature by virtue of the fact (?) that its *supposed* particles are in a given state of vibration or are moving with a given velocity and bombarding one another trillions of times in a second at 60 degrees Fahrenheit (for example); and in the case of hydrogen possessing at this temperature a velocity in their *free path* of over one mile in a second. Again, experiment has shown that the temperature of a body can be reduced, which means that the velocity of the particles composing the body has been diminished.

Now we have a right to inquire, and, in fact, it is our plain duty to do so, as to what condition the universe as a mass would be in, if deprived of all heat, or if reduced to the absolute zero of temperature.

There could be no motion: for, according to Tyndall, "Heat is a 'mode of motion;'" and any motion of the particles of a mass or of the mass itself (owing to friction) would produce heat, and that would not be the *absolute zero* of temperature; so we are compelled to admit that at such a point (or temperature, *i. e.*, condition) all motion would be destroyed and nothing but mass would remain, absolutely motionless and in a state of perfect tranquillity and rest.

What then is "motion" but a phenomenon?

None but an omnipotent power could store up in such a universe the necessary force to set the same in motion and maintain it so.

Just as by winding up the spring of a clock we store up force within it which is liberated when unwound; or just as force is stored up in a cannon ball when liberated from the explosion, so that the ball will possess *energy* by virtue of the stored-up force, thus enabling the mass to do work. It is not the "motion" of the mass that does the work, for such motion is incidental, but it is the constantly liberating force stored up in the ball that does the work. And if the cannon ball in motion set some body in its path in motion, it is because it has stored up in that body some of its force, thus enabling this newly moving body to do work itself.

The claim, therefore, that matter has always been in motion, and that the quantity of motion in the universe is a constant quantity, is irrational; for "motion" is not a "thing," it is a phenomenon; it has to be created; as Dr. Hall has said: "it never 'existed,' but sometimes 'occurs.'"

Given a man who can just lift five hundred and fifty pounds, and who attempts to impart an upward motion to a weight weighing six hundred pounds—he does not succeed; a child who can lift fifty pounds

joins him in his effort—when suddenly, the mass has a *motion* upward to the height they see fit to raise it.

What became of the energy expended by the man when attempting to lift the weight alone? We know what science would say, but let us look at the problem in a more advanced light.

Surely it is not the child who lifted the weight, neither was it the man alone—but it was the energy expended by both; the child overcoming a gravital pull of fifty pounds, and the man overcoming a gravital pull of five hundred and fifty pounds; *and just that amount of gravital pull was counterbalanced by the man when attempting to lift the weight alone, although he imparted no motion to the mass which remained at rest.*

When we inquire into the nature of *force*, we find a different state of affairs as compared to *motion*. The quantity of force in the universe is a *constant quantity*. Force is indestructible, cannot be added to or subtracted from, it is persistent, it is always active, observed or unobserved, always at work, tending to establish an equilibrium in nature.

Force is the *thing*, the "entity," not motion, which it can produce, "create," cause to "occur" in a mass. Prof. Tait has said: "It has been definitely established by modern science that heat, though not material, has objective resistance in as complete a sense as matter has." But the distinguished professor looks upon heat, light, sound, electric currents, etc., as forms of "energy." And here is where we will have to differ; for "energy" can only be the power, ability, capacity of force, acting through matter to do work. Matter is the vehicle in which force can be stored up and made to do work; and when force is thus stored, we speak of the energy of the mass; and just in proportion as there is more or less stored-up force within it, just in the same proportion is it capable of doing more or less work, or, in other words, is it possessed of more or less energy.

The two entities in this world are therefore force and matter. One active, possessed of kinetic energy; the other possessed of inertia or inability to act.

More confusing, absurd, and irrational hypotheses have been introduced into science than a few by the attempt to ignore the infinite and attempting to explain the phenomena of nature on a purely dynamic or mechanical basis.

If there was no other argument than the inability of the *finite* mind to grasp the immensity of space which knows no boundaries, we would be compelled to the admission of the existence of the infinite.

The *infinite* can no more be separated from his works than a *part* can make up a whole.

If the God I have the individuality to worship is not as Savage said, "in the dust of the streets, in the bricks of my house and in the beat of my heart, then he is not infinite." This, however, does not make the dust of the streets, the bricks of a house, or the beat of one's heart a God, any more than my hands, my feet, my stomach, which although quite necessary to make me a human being, are quite unnecessary to make me a living thing.

Neither does it make my hands, or feet, or stomach the ever-living "Ego," the "I," which proves that there is something within my material frame not acquired from outside of it.

In the same way does the universe find its existence in God—all force and matter being made out of his infinite substance. By this admission we are not led to say with Haeckel, "There is no God but Force"—but rather as Dr. McCosh has said, "There is no Force but God." And in the slightly modified words of a distinguished writer: Just as an image is sustained in a mirror by the constant succession of the rays of light, so nature is sustained by the putting forth of the power of God, which, if for one instant withdrawn, nature, in all her grandeur and complexity, would sink back into that simple condition from whence it arose.

There is one mystery that science must acknowledge and bow in respectful recognition to, and that is the mystery of the infinite. It is far better to admit one great mystery, and send back to that source such problems as surpass finite analysis, for solution in the future, than to attempt to ignore the Infinite in his works.

The universe is not a machine, and it can no more be run without the constant exercise of the will of God than a steam engine can be run with all the fuel in the world, except it be directed by the will of man.

[PHARMACEUTISCHE RUNDSCHAU.]

ON THE CHEMICAL CONSTITUENTS AND POISONOUS PRINCIPLE OF THE BARK OF ROBINIA PSEUDACACIA, LINN.

(*Common Locust or False Acacia.*)

By Professor Dr. FREDERICK B. POWER and JACOB CAMBIER.*

THE bark of the common locust appears never to have been subjected to a chemical examination, and our attention has now been especially directed to it in consequence of some recent observations concerning its poisonous properties. It was reported, for example, about three years ago, by Dr. Z. T. Emery,† that "Thirty-two boys at the Brooklyn Orphan Asylum became poisoned by chewing the inner bark of this tree, which they had obtained from the yard where fence posts had been stripped. In the mildest cases vomiting of ropy mucus was observed, together with flushed face, dryness of throat, and dilated pupils. In the severest cases large quantities of ropy mucus mixed with blood were vomited; the other symptoms were retching, pain in the epigastrium, debility, stupor, extremities cold and pulseless, heart's action feeble and intermittent, pupils dilated, faces of a dusky pallor. The patients were given bismuth subcarbonate and brandy by the mouth, and morphine hypodermically; sinapisms were applied over the stomach, and bottles with hot water along the extremities. The patients were discharged from the hospital in two days."

There are, however, some earlier observations recorded relating to the toxic properties of this bark, as, for example, in the "National Dispensatory," third edition, p. 1312, where we find the statement that "the bark of the root is said to be tonic, and in large doses purgative and emetic. Gendron mentions that boys who had chewed some of the bark and swallowed the juice were affected not only with vomiting, but coma and slight convulsions." In the U. S. Dispensatory, XV. edition, p. 1740, it is stated that "three cases of poisoning in children who had eaten of the root‡ by mistake have been recorded. The symptoms were like those produced by an overdose of belladonna; but all the children recovered. One of them, who happened to be laboring under intermittent fever at the time, had no return of the paroxysms afterward." (Ann. de Therap., 1860, p. 64.)

In King's "American Dispensatory," tenth edition, 1875, p. 713, the properties and uses of locust bark are described as follows: "A decoction of the root is tonic in small doses, but emetic and purgative in large ones. An ounce of the bark boiled in three gills of water operates as a cathartic in doses of half an ounce given morning and evening. The bark is supposed to possess some acro-narcotic properties, as the juice of it has been known to produce coma and slight convulsions. An overdose has produced symptoms very similar to those resulting from an improper dose of belladonna, and at the same time cured a case of fever and ague. The *leaves* operate mildly and efficiently as an emetic in doses of 30 grains every 20 minutes."

In Millspaugh's "American Med. Plants," 1885, p. 52, the statement of Dr. A R. Ball is recorded that "Robinia causes extreme nausea, profuse acid vomitings, fluid eructations, and purging. The symptoms followed eating of the bark." In the same work, *loc. cit.*, it is also noticed that Dr. Shaw (*Med. Times and Gazette*) had observed the following effects in a child who had eaten of the *seeds** of the Robinia: "Inability to hold the head upright, nausea and attempts to vomit, with a tendency to syncope when in an upright position; voice, respiration, and heart's action feeble, as from exhaustion; a painful paralytic condition of the extremities, which became shrunken on the fifth day. All the symptoms seemed like those produced by a long-continued diarrhea, although in this case purging was not present."

In connection with these observations may be mentioned an item contained in a newspaper of this State (Wisconsin) of very recent date, to the following effect: "A farmer, while stopping at the cemetery in Green Lake county, hitched his team to a locust tree on the grounds. On his return home both horses were taken violently sick, and were soon suffering with spasms. By hard work it was possible to save the life of one, but the other died. The symptoms of both were those noticeable in cases of poisoning, and it is concluded that the horses must have nibbled some of the locust bark and swallowed it. The bark of the locust tree is said to be a virulent poison at the season when the sap oozes from the tree."

Nothwithstanding these statements of the poisonous properties of locust bark they appear to be very little known, for inquiries made by us among both farmers and physicians in our locality, where the locust tree is found abundantly along roadsides, have failed to afford any further information in this particular. It was, therefore, with a desire to ascertain to what principle the above mentioned poisonous properties could be attributed that this investigation of the bark was undertaken.

The *Robinia Pseudacacia*, Linn., or common locust, belongs to the family of Leguminosæ, and is a tree so well known both in this country and in Europe that its specific botanical characters need not here be described, especially as the latter are to be found in all the manuals of botany. It is known in different parts of this country by the popular names of yellow, black, red, green, and white locust, terms which are stated to refer to the variation in color of the heart wood.

The generic name *Robinia* was bestowed upon this tree by *Linnaeus* in honor of Jean Robin, a French botanist, once herbalist to Henry IV. of France. The specific name *pseudacacia* is derived from the Greek ψευδός, false, and *acacia* (from the Greek ἀκή, a point), with reference to the resemblance of the trees of this genus to the true African acacias.

According to Michau, "North American Sylva," Vol. II., p. 92, the locust begins to grow naturally in Pennsylvania in the latitude of 40° 20′. West of the mountains it is found 2 or 3 degrees further north. But the locust is most multiplied in the southwest, and abounds in all the valleys between the chains in the Alleghany Mountains. It is also common in all the Western States, and in the territory comprised between the Ohio, the Illinois, the Lakes, and the Mississippi.

Professor Charles S. Sargent, in his "Report on the Forests of North America," tenth census of the United States, Vol. IX., 1880, p. 55, refers to the distribution of *Robinia Pseudacacia* as follows: "The Alleghany Mountains, Pennsylvania to northern Georgia; widely and generally naturalized throughout the United States east of the Rocky Mountains, and possibly indigenous in northeastern and western Arkansas, and the prairies of eastern Indian Territory."

It is further stated by Michau (*loc. cit.*) that the locust was one of the first trees introduced into Europe from the forests of North America, east of the Mississippi, and that the seeds were received from Canada by J. Robin, and cultivated by him on a large scale about the year 1601. According to others, the seeds were sent to Vespasian Robin (son of the preceding), who was arborist to Louis XIII., and that they were planted by him in the "Jardin des Plantes" in Paris in 1635. Since this period it has become extensively propagated, and is now universally known in France, England, and Germany.

The wood of the locust tree, which is commonly of a greenish-yellow color, is very hard, compact, and susceptible of a brilliant polish. It possesses great strength, with but little elasticity; and its most valuable property is that of resisting decay longer than almost any other species of wood. It has, therefore, been highly esteemed in naval architecture, in cabinet making, and for the construction of fence posts. It is also stated that most of the houses which were built at Boston in the first settling of the English were constructed of this timber.

An interesting economic application of the foliage of the locust tree, especially when considered in connection with the observed poisonous properties of the bark, is that recorded in a pamphlet entitled "Memoir on the Common Acacia," published at Paris in 1786, in which the author recommended it as a substitute for *sain foin*, as a forage crop, to be mown thrice a year, and either used green, or dried, as hay, and stacked, mixed with straw, for winter use. Another writer, D. J. Brown, in "The Trees of North America," New York, 1846, also states that "in countries where clover and root crops are not cultivated, the leaves of the locust may serve as a substitute for these articles as provender for animals. When this species (*R. Pseudacacia*) is cultivated for this purpose, it should be mown every year; or the trees may be allowed to grow to the height of eight or ten feet, and treated as pollards, the branches being cut off every other year, which should be done at midsummer when they are succulent, and can be dried for winter's use. When the shoots are to be eaten green, none should be taken but those of the same season; because in them the prickles are herbaceous, and consequently do not injure the mouths of the animals." In Don's "Gardener's Dictionary," London, 1832, Vol. II., p. 237, it is also stated that "the leaves afford wholesome food for cattle."

In view of these applications it would not seem possible that the foliage of the locust tree can partake of the poisonous properties of the bark, although, as we have already seen in King's "American Dispensatory," it is stated that "the leaves operate mildly and efficiently as an emetic in doses of 30 grains every 20 minutes." These apparently conflicting statements concerning the properties of the leaves of the locust tree, therefore, present a subject for further investigation.

The literature relating to the species of *Robinia* under notice is thus seen to be quite extensive, and of considerable interest. Its history and geographical distribution, together with the poetical and legendary allusions, methods of propagation and culture, properties, uses, etc., are noticed at considerable length in the previously mentioned work of D. J. Browne, "Trees of North America," pp. 195–208. Other references of interest which may here be briefly cited are contained in Michau's "North American Sylva," Vol. II., p. 92, and in the following "Reports of the U. S. Department of Agriculture": (1857) pp. 270, 490, 491. (1860) p. 420. (1863) p. 48. (1864) p. 343. (1868) pp. 92, 201, 203. (1870) p. 76. (1875) p. 159.

BOTANICAL AND PHYSICAL CHARACTERS OF THE BARK.

The bark of the trunk and large limbs of well developed locust trees is quite thick, and consists of a dark brown, deeply and irregularly furrowed corky layer, beneath which is an almost colorless layer of inner bark, about $\frac{1}{10}$ of an inch in thickness, which can be readily separated. The entire bark usually separates readily from the wood, and can often be detached from the trees in strips many feet in length. The inner bark possesses when fresh a peculiar, not unpleasant, odor and a slightly sweetish, mucilaginous taste. When dry it has a slight yellowish-brown color, and is smooth on the inner surface; it is tough and fibrous, not easily broken transversely, but may readily be torn into strips.

CHEMICAL EXAMINATION OF THE BARK.

The bark used in this investigation was collected by ourselves from trees in the neighborhood of Madison, Wis., where, as previously stated, it is found as a cultivated tree along roadsides, in the vicinity of farm houses, as also in the town, but is evidently not indigenous to this section. The portion of the bark employed consisted exclusively of the light colored inner or younger portion, or liber, the brown, tasteless, and probably inert suberous layer being rejected. The fresh bark loses on drying, by exposure to the air, 35 per cent. of its weight.

A. Examination for Alkaloid.—Some preliminary experiments having afforded indications of the presence of small amounts of alkaloid in the bark, a larger quantity of material was treated in the following manner:

I. Five kilogrammes of the coarsely ground bark were extracted in a copper still with boiling alcohol, the contents of the still then expressed, and the alcoholic liquid filtered. The latter was of a light yellow color, and from it the greater part of the alcohol was subsequently recovered by distillation. The alcohol thus recovered possessed a peculiar, disagreeable, somewhat fishy odor, but was neutral to litmus.

The concentrated alcoholic extract, which was of a dark brown color, separated on cooling a considerable amount of a light colored *fatty matter*, which was filtered off. This fat was readily saponified in alcoholic solution by caustic soda, and from the resulting soap the fatty acids were obtained in a perfectly colorless form, but were not further examined.

The above-mentioned alcoholic extract was then brought into water acidulated with sulphuric acid, when some resinous matter was precipitated in a flocculent form, but, after being collected on a filter, it formed a soft, sticky mass of a dark brown color. The liquid filtered from the resin was subsequently deprived of the excess of sulphuric acid by digesting it with barium carbonate, again filtered, and evaporated on a water bath to a small volume. This concentrated aqueous liquid was of a dark brown color, and, in order to further purify it, it was treated successively with neutral and basic lead acetates. The neutral lead acetate produced an abundant brown precipitate, which was filtered off, and in the filtrate therefrom basic lead acetate then produced a further precipitate of a yellowish color.

These lead compounds were collected separately, thoroughly washed with water, and afterward suspended in water, and decomposed by hydrogen sulphide. The aqueous solutions of both of the decomposed lead compounds were of a reddish yellow color, but on evaporation afforded simply amorphous, dark brown residues. The coloring matter precipitated by neutral lead acetate was found to be a glucoside; it gave

* Read before the Wisconsin Academy of Sciences, Arts, and Letters, Dec. 27, 1889.

† *New York Medical Journal*, Jan. 22, 1887, and *Amer. Jour. Pharm.*, 1887, p. 153.

* It would seem somewhat more probable that the bark of the stem is here intended, as the root of the tree is rarely found above the surface of the soil, and would not be easily accessible to children.

† It is quite remarkable that children should be tempted to eat the seeds of the Robinia, as in the unripe state they possess simply a bean-like taste, and when fully ripe they are hard and most unpalatable.

a slight brown coloration with ferric chloride, was darkened in color by alkalies, and was slightly precipitated by gelatin, thus indicating the presence of a small amount of *tannin*. The coloring matter precipitated by basic lead acetate showed a similar behavior, with the exception of not being precipitated by gelatin. Neither of these principles, therefore, correspond with the glycoside *robinin* which was separated by Zwenger and Dronke* from the flowers of *Robinia Pseudacacia*, and stated by them to form yellow, silky needles, sparingly soluble in water, and to be precipitated by basic lead acetate.

We have also sought to obtain this principle from the flowers by the method pursued by the above-mentioned chemists, but could not succeed in obtaining the coloring matter in a crystalline form. The flowers are especially rich in a non-crystallizable sugar, which readily reduces alkaline solutions of cupric oxide on heating.

The liquid obtained from the bark, and treated with both neutral and basic lead acetates, as above described, was subsequently saturated with hydrogen sulphide to remove the excess of lead, and again filtered. It now possessed but a slight yellowish color, but on further evaporation it acquired a dark brown color and a sirupy consistence. When acidulated with hydrochloric acid it afforded the following reactions indicative of the presence of an alkaloid: with potassium bismuth iodide a brick-red precipitate, with potassio-mercuric iodide a white precipitate, with iodine in potassium iodide a brown precipitate, and with phospho-molybdic acid a yellowish precipitate.

The acid solution of the alkaloid was subsequently shaken with ether, then made alkaline, and again successively shaken with both ether and chloroform. The ether separated from the acid solution left on evaporation a very small amount of a crystalline residue which afforded the reactions of an alkaloid. The ether separated from the alkaline solution left on evaporation a slight amorphous residue, having a peculiar odor, and which, when dissolved in acidulated water, likewise gave the reactions of an alkaloid. The residue obtained by the evaporation of the chloroform separated from the alkaline solution was similar to that obtained by means of ether. The aqueous liquid thus treated, when again acidulated, afforded, however, nearly as strong an alkaloidal reaction as before, which showed that the alkaloid is taken up to but a very small extent by these solvents, and that it could not be readily extracted by this method.

The acid solution was accordingly precipitated by a solution of potassio-mercuric iodide, which had previously been saturated with mercuric iodide by heating it with a slight excess of the latter, since such a solution was found to precipitate the alkaloid more completely.

The light yellowish precipitate thus obtained was collected on a filter, and washed with water slightly acidulated with sulphuric acid. The filtrate from the precipitate so obtained was found to still afford an abundant brick red precipitate with potassium bismuth iodide, and the latter reagent was therefore added so long as a precipitate continued to be produced. This precipitate was likewise collected and washed with acidulated water.

Both of these precipitates were subsequently suspended in water, and decomposed by hydrogen sulphide, the liquids filtered, concentrated on a water bath, and afterward allowed to evaporate over sulphuric acid. After standing for two days the liquids became quite dark in color, owing to the decomposition of the free hydriodic acid present, and it was also seen that the hydriodide of the alkaloid showed no disposition to crystallize.

The solution of the hydriodide of the alkaloid obtained from the compound produced by potassio-mercuric iodide was taken up with water, and treated with freshly precipitated silver oxide, the liquid filtered, and the filtrate neutralized with hydrochloric acid; the latter served not only to separate the small amount of silver oxide dissolved in the liquid, but also to convert the free alkaloid formed into the hydrochloride. This solution was then allowed to evaporate over sulphuric acid, when a few small colorless crystals were obtained, which appeared to be somewhat deliquescent. The liquid from which these crystals were obtained was evaporated on a water bath, the residue extracted with strong alcohol, and this solution precipitated with an alcoholic solution of platinic chloride. The precipitate produced by the latter, which was of a lemon-yellow color, was afterward redissolved in water, and from this solution the platinum compound was obtained in orange red prismatic needles.

This salt contained no water of crystallization, and on examination was found to contain an amount of platinum and chlorine agreeing approximately with that required for the platinum compound of *choline*, namely: $(C_5H_{14}NOCl)_2 PtCl_4$.

A small amount of the hydrochloride of the alkaloid (0·007 gramme) when brought beneath the skin of a frog in the dorsal thoraco-lumbar region produced no perceptible physiological action. This, however, was not surprising, since Brieger† has shown that it requires 0·05 gramme of choline hydrochloride to produce in a frog its peculiar effect, which is paralysis, with a quite rapid reduction of the contractions of the heart, and final complete cessation of the latter in diastole.‡

The supposed identity of this alkaloid with choline was further confirmed by the results of the following subsequent experiments.

The solution of the hydriodide of the alkaloid obtained from the compound produced by potassium bismuth iodide, as previously described, when allowed to evaporate over sulphuric acid also showed no tendency to crystallize. It was, therefore, treated with silver oxide, and the solution of the free base converted into the hydrochloride, which was obtained in the form of fine, silky needles, permanent in the air.

The aqueous solution of this salt shows the following behavior to alkaloidal reagents: With potassio-mercuric iodide it affords a yellowish white precipitate, with potassium bismuth iodide a brick red precipitate, with iodine in potassium iodide a brown precipitate, with phospho-molybdic acid a yellowish precipitate, with picric acid a bright yellow precipitate, and with tannic acid a grayish white precipitate. The liquid from which the crystals of the hydrochloride of the alkaloid had been obtained was evaporated on a water bath, extracted with strong alcohol, and precipitated with an alcoholic solution of platinic chloride.

The resulting lemon-yellow precipitate was washed with small portions of alcohol, and recrystallized from water, when it was obtained in the form of orange red prismatic needles.

This salt contained no water of crystallization, and, after drying at 110° C., two estimations of the platinum afforded 31 57 and 32·15 per cent. respectively. An estimation of the chlorine gave 35 6 per cent. The amount of the salt available was not sufficient for a further ultimate analysis, but the results of the above estimations agree quite well with the theoretical requirements of the platinum compound of choline.

Calculated for $(C_5H_{14}NOCl)_2 PtCl_4$		Found I.	Found II.
Pt (194·4	= 31·58 p.c.	31 57 p.c.	32·15 p.c.
Cl	= 34·6 p.c.	35·6 p.c.	—

The hydrochloride of this alkaloid differs from the choline of animal origin by its permanence in the air, but on the other hand it agrees in this respect with the so-called *iso-choline* separated by Brieger from ergot.* It also agrees with choline in its behavior to alkaloidal reagents, with the single exception of being precipitated by tannic acid, which Brieger states is not the case with choline of animal origin, and serves to distinguish choline from neurine.†

Another process for the separation of the alkaloid was now tried, as follows:

II. One kilogramme of the coarsely ground bark was digested in the cold for twenty-four hours with two successive portions of milk of lime, strained, filtered, and the filtered liquid, after neutralization with sulphuric acid, concentrated on a water bath. It was then made alkaline with solution of potassa and shaken with three successive portions of ether, which left on evaporation a slight sirupy residue of a brownish color. This was dissolved in acidulated water, and afforded the reactions of an alkaloid, but the amount thus separated was too small for further examination. The original aqueous liquid was, therefore, again acidulated with sulphuric acid, and gently heated to expel the ether, when it was found to be abundantly precipitated by potassium bismuth iodide. The precipitate produced by the latter was collected on a filter, washed with aciduated water, and then suspended in water and decomposed by barium carbonate, and filtered. The filtrate was then treated with silver sulphate, again filtered, and the excess silver sulphate remaining in the solution separated by hydrogen sulphide. After expelling the latter by a gentle heat, the alkaloid was liberated by baryta water, then filtered, and the excess of baryta separated by carbon dioxide. The clear liquid was now evaporated on a water bath, when it finally acquired the consistence of an extract, possessed a dark brown color, a peculiar odor, and a strongly alkaline reaction. This extract was treated with absolute alcohol, and the alcoholic solution allowed to evaporate, when a soft extract-like substance was again obtained, which possessed the color, odor, and strongly alkaline reaction of the original substance. The weight of the portion soluble in absolute alcohol was 0·45 gramme, or representing 0 045 per cent. of the bark. The portion of the extract not soluble in absolute alcohol was taken up by dilute alcohol, and amounted to 0·8 gramme or 0 08 per cent. of the bark. It also possessed an alkaline reaction, and, like the portion soluble in absolute alcohol, when acidulated, afforded the reactions of an alkaloid. The character of these extract-like substances will be further considered in connection with the product obtained by the following process:

III. One kilogramme of the coarsely ground bark was extracted by digesting in the cold for two days with water strongly acidulated with sulphuric acid. The strained and filtered liquid, which was of a light brown color, was concentrated on a water bath, when a considerable amount of resinous matter was separated. The clear liquid was then precipitated by potassium bismuth iodide, and the voluminous red precipitate thus obtained was subsequently treated as described in process II. The final product also resembled that obtained in process II., forming an extract-like mass, having a peculiar odor and strongly alkaline reaction. The portion soluble in absolute alcohol amounted to 1·12 gramme, or 0·112 per cent. of the bark, while that dissolved by dilute alcohol amounted to 1·5 gramme, or 0·15 per cent. of the bark.

A portion of each of the extract-like substances soluble in absolute alcohol was tested with various reagents, such as concentrated acids, etc., but gave no special color reactions. When dissolved in water, it appeared to possess the properties of a strong base, affording precipitates with solutions of the salts of many of the heavy metals, but when portions were neutralized with sulphuric, nitric, hydrochloric, and hydrobromic acids respectively, only amorphous, dark colored extract-like bodies were obtained. Similar results were obtained with that portion of the original extract-like substance which was taken up by dilute alcohol.

In order to test whether these products possessed any physiological action, 0·1 gramme of both the portion soluble in absolute alcohol and that soluble in dilute alcohol was injected hypodermically into a small frog, but without producing the least disturbance in the animal. It was, therefore, evident that they possessed no marked toxic properties. Notwithstanding the extended manipulations of the process by which these substances were obtained, the results of subsequent observations rendered it probable that they represented simply an impure form of choline, associated with a considerable amount of albuminoid matter.

(*To be continued.*)

* See "Die Pflanzenstoffe," by Husemann and Hilger. Second edition, p. 1046.

† Brieger, "Untersuchungen uber Ptomaine," III., p. 17.

‡ Ibid., I., p. 38.

* "Untersuchungen uber Ptomaine," III., p. 107. See also Mutterkorn in the "Real Encyclopadie der gesammten Pharmacie." Vol. 7, p. 179.

A base isomeric with choline, and designated as iso-choline, has also been obtained by G. Mayer by a synthetical process, but has not yet been further examined. (See "Aldehydammoniumbasen" in *Ber. d. deutschen Chem. Ges.*, 1883, p. 207.)

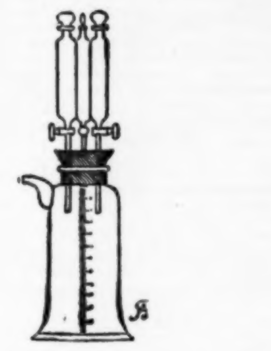
† Brieger, "Ueber Ptomaine," I., pp. 35–38.

A SIMPLE APPARATUS FOR GENERATING OXYGEN GAS.

C. F. GOHRING recommends the below-described method and apparatus for preparing pure oxygen gas on a small scale.

A large flask with spout, of the shape shown in the cut, and graduated, is provided with a rubber stopper through which three stoppered funnels pass. The latter are filled, respectively, with concentrated water of ammonia, solution of permanganate of potassium (5 gm. in 1 liter), and concentrated phosphoric acid. In order to afford to the eye a criterion to ascertain when the contents of the flask or reservoir are alkaline or acid, the ammonia may be tinted with phenolphthalein, or the phosphoric acid with methyl-orange. The flask or reservoir is filled about two-thirds full with peroxide of hydrogen solution.

To generate oxygen, ammonia is allowed to flow

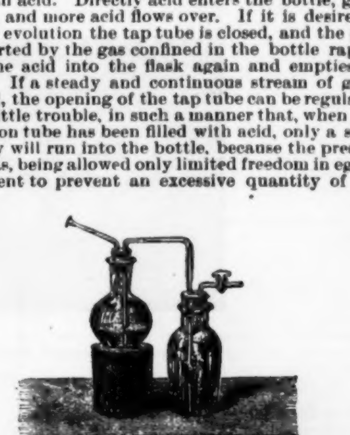


into the flask until the contents are rendered alkaline (and show the phenolphthalein tint, if this indicator has been used). Solution of permanganate is then allowed to flow in, in drops, when oxygen will at once be given off, which may be conducted by suitable tubing to where it is wanted. When the current is to be interrupted, enough phosphoric acid is allowed to run in to neutralize the ammonia and render the liquid acid. When the current is to be started again, the liquid need only be supersaturated with ammonia. Thus the current may be started and stopped until the peroxide is exhausted.

If the strength of the peroxide has once been determined by acting upon a measured quantity in the flask by the process here described, it will be easy to predetermine the quantity of peroxide to be used in order to obtain a certain quantity of oxygen.—*After Chem. Centralbl.*, 1889, 114 (*from Chem. Zeit.*)

SUBSTITUTE FOR KIPP'S APPARATUS.

THE accompanying sketch represents a simple contrivance for supplying a continuous and steady stream of carbonic acid. The flask, with a capacity of 500 to 600 c. c., contains hydrochloric acid. The bottle, fitted with a tap tube, contains chips of marble. They are connected by a tube in the form of a siphon reaching to the bottom of each. The flask is also provided with a tube similar to the shorter tube of a wash bottle, and for a similar service; it has been represented in its present position for convenience in drawing, but should be turned through 90° toward the reader for convenience in operation. When the evolution of gas is required, the tap tube is opened and the pressure within the flask increased just sufficiently to fill the siphon tube with acid. Directly acid enters the bottle, gas is evolved, and more acid flows over. If it is desired to stop the evolution the tap tube is closed, and the pressure exerted by the gas confined in the bottle rapidly drives the acid into the flask again and empties the siphon. If a steady and continuous stream of gas is required, the opening of the tap tube can be regulated, with a little trouble, in such a manner that, when once the siphon tube has been filled with acid, only a small quantity will run into the bottle, because the pressure of the gas, being allowed only limited freedom in egress, is sufficient to prevent an excessive quantity of acid



THOMPSON'S SUBSTITUTE FOR KIPP'S APPARATUS.

from flowing in. But, as the hydrochloric acid in the bottle becomes saturated with calcium chloride, its action becomes less vigorous, and the pressure of gas would be diminished but for the fact that additional acid, thus permitted to flow over very gradually, is just sufficient to keep it at the same height.

In the same apparatus, the marble may be replaced with zinc or with sulphide of iron for the preparation of hydrogen or of sulphureted hydrogen respectively. It is, in fact, a simple substitute for Kipp's apparatus. One advantage, not altogether inconsiderable, which gives it a preference to the latter, is that it requires a far smaller quantity of acid; that which has not dissolved calcium, iron, or zinc chloride, remaining in the flask till required, does not mix readily with the portion already saturated, and when all is saturated, it is easily replaced by a fresh quantity.—*Eustace Thompson, in Chem. News.*

HEAT DILATATION OF METALS FROM LOW TEMPERATURES.

By THOMAS ANDREWS, F.R.S.

IT is understood that the coefficients of heat dilatation increase with rise of temperature; but Professor P. G. Tait, in his recent work on *Heat*, page 87, remarks that "we are not aware of any experiments made with a view of deciding whether, as is probable, these coefficients become gradually less as the temperature is lowered below zero" (0° C.) The following experiments were made to investigate the subject in relation to metals of the iron and steel series. The varieties of modern steels manufactured by recent processes manifest properties sufficiently diverse as almost to constitute them distinct groups of metals, although for practical purposes they are conveniently grouped under the generic name of steel. Some of these modern metals have recently been so largely used for constructive purposes that the author considered it desirable to obtain an approximate quantitative estimation of their dilatation by heat through varied ranges of temperature. The rolled metals under observation in the experiments consisted of round polished bars, 3 inches in diameter and 13 inches long, planed perfectly square at each end; they were carefully manipulated during manufacture, and were selected from the author's standard samples, having the chemical composition given in table I.

The range of temperature chosen for the observations was from 45° C. to 300° C. The experiments were conducted as follows: For the measurements commencing at the low temperature of —45° C., the bars (having previously been slowly reduced to the temperature of 0° C., and then gradually cooled to —18° C.) were placed upright in the bath A (see illustration), and immersed in a freezing mixture of three parts of calcium chloride and two parts of snow, each of these ingredients, previous to mixing, being maintained in separate jacketed freezing tanks at a temperature of —18° C. The vessel, A, containing the bars and the calcium chloride freezing mixture, was further surrounded by another compartment holding a quantity of a freezing mixture of snow and salt at a temperature of —20° C. By this means and by constantly renewing the calcium chloride and snow mixture during the experiments, a uniform temperature of —45° C., as registered by an alcohol thermometer, was maintained for the experiments in the cold bath, A. Much larger cooling tanks of a snow capacity for each charge of 8 cwt. were used for the large forgings, and a large cast metal oil bath having a capacity of about 70 gallons of oil was used for the highest temperature.

The bars remained thus immersed in the freezing bath while their internal temperature was regularly ascertained by another alcohol thermometer placed in a hole in the center of the test bar, C, wherein was also placed a little alcohol. When the bars had reached and remained for some time at the registered temperature of — 45° C., each was in turn removed and placed on a suitable wooden frame, and its length instantly and carefully measured by telescopic readings from a delicate micro-vernier gauge (deviations of $\frac{1}{5000}$ of an inch were perceptible), also supported on a suitable rigid stand. The bars were then replaced for a short time in the freezing mixture, and again removed, and their diameter then carefully measured. No perceptible alteration in the temperature of the bars occurred during the very short time occupied in taking the observations, and frequent tests were made to ascertain this. The average of about thirty measurements in each case, both longitudinal and transverse, was regarded as fairly accurate.

The dimensions of the bars were taken in a similar manner for the temperature from — 18° C., substituting in another cold bath, B, a freezing mixture of snow and salt to obtain this temperature, and using powdered ice and snow for the observations at 0° C. The higher temperature observations were obtained by heating the whole of the bars in a large hot water bath for the period necessary to insure that their temperature throughout was as required, and the oil bath was used for the temperature of 300° C. Liability to temperature errors was, as far as possible, carefully guarded against by constant reference and comparison between the bath thermometers and that in the center of the test bar, and by keeping the bars immersed during sufficiently long periods.

The hammered metals under observation were large forgings of the different metals, 7 feet 3 inches long, and 5 inches in diameter, planed perfectly square at the ends and turned and polished bright. The measurements were taken on the total length of the forging, as in the case of the rolled metals, to insure greater accuracy, the experiments being conducted in somewhat similar manner; but owing to the greater length of the forgings, a modification of the method was made. One end of the forging was rigidly secured and the expansion ascertained by measuring the diminishing space between the other end of the forging and a fixed point situated a distance from it. The results are recorded in table II.

TABLE I.—ANALYSES OF WROUGHT IRON, STEELS, AND CAST METALS EMPLOYED.

Rolled Bars.

Description.	Graphitic Carbon.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.	Iron (by Difference).	Total.	Specific Gravity.
Wrought iron (Wortley best scrap)	—	None	0·392	0·034	0·27	0·194	99·11	100	7·69
Bessemer steel, soft*	—	0·15	0·009	0·112	0·088	0·468	99·173	100	7·853
„ „ hard	—	0·48	0·121	0·096	0·089	0·684	98·530	100	7·838
Siemens-Martin steel, soft ...	—	0·23	0·014	0·1	0·075	0·698	98·883	100	7·856
„ „ hard ...	—	0·46	0·107	0·023	0·075	0·972	98·363	100	7·845
Cast steel, soft	—	0·45	0·016	0·027	0·048	0·086	99·373	100	7·863
„ hard	0·259	1·19†	0·175	0·063	0·019	0·396	97·898	100	7·805
Cast metal, best	2·78	0·39†	2·34	0·09	0·58	0·45	93·37	100	7·206
„ common	2·62	0·67†	1·94	0·09	0·95	0·52	93·21	100	7·134
Hammered Forgings.									
Wrought iron (Wortley best scrap)	—	0·038	0·117	0·019	0·246	0·112	99·468	100	—

* The terms "soft" and "hard" relate only to difference of percentage of combined carbon, and not to any annealing or hardening processes. The metals were so prepared as to obtain a wide difference in the percentage of combined carbon between the soft and hard varieties.

† Combined carbon in these samples was determined by combustion, and in the other samples by the colour test.

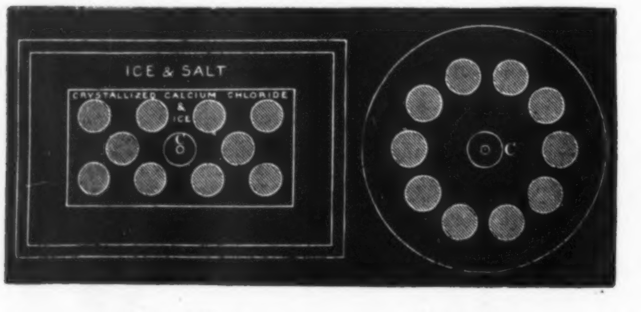
TABLE II.

Rolled Bars.

Description.	Coefficients of Linear Dilatation for 1° C. between.			1,000 Parts at - 45° C. became at 300° C.	
	- 45° and 100° C.	- 18° and 100° C.	100° and 300° C.	Longitudinal.	Across the Diameter.
Wrought iron (Wortley best scrap) ...	0·0000086	0·0000114	0·0000133	1003·638	1003·588
Bessemer steel, soft	0·0000093	0·0000117	0·0000159	1004·133	1003·944
„ hard	0·0000085	0·0000101	0·0000133	1003·746	1004·322
Siemens-Martin steel, soft	0·0000088	0·0000116	0·0000144	1003·807	1003·946
„ hard	0·0000079	0·00001	0·0000139	1003·731	1003·57
Cast steel, soft	0·0000086	0·0000112	0·000015	1003·755	1003·502
„ hard	0·0000084	0·0000101	0·000013	1003·577	1003·411
Cast metal, best	0·0000088	—	0·0000137	1003·637	1003·621
„ common	0·0000088	0·000009	0·0000152	1003·784	1003·579
Large Hammered Forgings.				1,000 Parts at 0° C. became at 300° C.	
				Longitudinal.	Across the Diameter.
Wrought iron (Wortley best scrap) ...	0·0000096	0·0000117	0·0000131	1003·944	1003·537
„ „ „ * ...	0·0000081	0·0000104	0·0000157	1003·79	1003·33
Bessemer steel	0·0000099	0·0000107	0·0000137	1003·829	1003·601
Siemens-Martin steel	0·0000093	0·0000113	0·0000142	1003·953	1003·641

* This was a smaller forging, only 3 inches in diameter and 13 inches long.

Bath A for temperature of —45° C. Bath B for temperature of —18° C.



Ground Plan. Ground Plan.
Scale, ¾ inch = 1 foot.

GENERAL REMARKS.

It is interesting to notice that the coefficients of dilatation were greater in the case of the soft than the hard steels, a circumstance which may be accounted for by a reference to table I. of the analyses, from which it will be seen that the percentage of combined carbon was much lower in the soft than in the hard steels, the percentage of pure iron was consequently also greater in the soft steels; this caused them to be of a greater specific gravity. The results in table II. appear also to indicate another circumstance of metallurgical interest, viz., that the dilatation was generally rather more in the direction of the length of the metallic cylinders than when measured across the diameter; numerous repeated experiments confirmed this. The result appears more marked in the large round forgings of hammered steels and wrought iron than in the case of the rolled bars. It would therefore seem probable that the crystalline particles of the metals suffer slight permanent alteration of form in the direction of their length during the process of rolling or drawing out, sufficient to very slightly affect their relative longitudinal and transverse dilatations. Furthermore, the observations of this memoir, conducted at these very low temperatures, experimentally confirm the suggestion of Professor Tait, inasmuch as the coefficients of dilatation were found generally to decrease with the reduced temperature below 0° C. The author also found such to be the case in his observations on the "Heat Dilatation of Pure Ice from Very Low Temperatures." It may be remarked that many tons of the various freezing mixtures, snow, etc., were required for the experiments.

A NEW FORM OF SIEMENS FURNACE.*

By JOHN HEAD.

IT would be necessary to write a complete history of the regenerative gas furnace to give any idea of the diversity and difficulty of the problems which Sir William and Mr. Frederick Siemens had to solve before their furnace, now so well known to iron and steel manufacturers, was made available for use in metallurgical operations. Among these problems may be instanced the preliminary heating of the gas as well as of the air, so as to introduce both of them into the heating chamber at a high temperature, the form necessary to be given to the regenerators in order that the heat should be deposited and recuperated in a methodical and rational manner, the arrangements for reversing the direction of the flame and for effecting a uniform diffusion of its heat throughout the heating chamber, all of which, simple as they now appear, involved a large amount of careful consideration on the part of the Messrs. Siemens. Besides these main features that had to be discovered and applied, we are also indebted to them for all the details that constitute the indispensable accessories used in the construction and working of the regenerative gas furnace. By their work the employment of reactions and metallurgical operations, foreshadowed by chemical research, have been rendered possible and practicable, which but for their furnace could have had no practical application, and would therefore be unavailable to manufacturers.

The great economical idea embodied and carried out in the regenerative gas furnace is perhaps best illustrated by comparison with such a meritorious invention as Neilson's hot blast stove. In this case the temperature of the blast was raised by means of fuel separately burned for that purpose, but in the case of the Siemens regenerative gas furnace the heat below the temperature of the work carried on in the furnace is impounded in the regenerators, and applied to heat up the gas and air supporting combustion. In high temperature furnaces the heat below the temperature of the work to be performed therein is by far the largest proportion of the total heat produced, and previously to the introduction of the Siemens furnace this heat had been lost by being allowed to pass away with the waste gases to the chimney. This circumstance was clearly explained by Lord Armstrong at the meeting of the British Association at Birmingham in 1865. By heating the inflowing gas and air, the temperature of the flame in a furnace may be raised to almost any extent; in fact, the heat attainable under these conditions is only limited by the power of resistance of the materials of which the furnace is built, and thus the highest temperatures required in metallurgical operations are obtained with facility by the expenditure of a moderate amount of fuel, especially since the introduction by Mr. Frederick Siemens of the method of heating by radiation, by which means the durability of the furnace has also been much increased. In considering the details of construction of this ingenious apparatus, it occurred to Mr. E. Biedermann and Mr.

* Paper recently read before the South Staffordshire Institute of Iron and Steel Works Managers.

E. W. Harvey, who are on Mr. Frederick Siemens' technical staff, that possibly further economy in fuel might be realized by a rearrangement of some of the parts of the regenerative gas furnace. Their attention was directed to the conversion of solid fuel into the gas in the producer and to the relatively high temperature at which the products of combustion passed from the furnace into the regenerators, as also to the chemical composition of these products, which temperature and gases they thought might be utilized in the gas producer.

As is well known, the production of carbonic oxide in the ordinary gas producer is the result of the decomposition of the carbonic acid formed in the first instance above the grate by incandescent carbon in the upper portion of the producer, according to the equation $CO_2 + C = 2CO$. Carbonic acid at a high temperature is produced with the development of heat in the lower layers of the fuel, which is transformed with the absorption of heat into carbonic oxide in traversing the red hot fuel above, while hydrocarbons are distilled from the coal used, and leave the producer with the carbonic oxide produced. In the new form of Siemens furnace the gaseous products of combustion from its heating chamber are delivered under the grate of the producer.

These gases consist of carbonic acid, water in the gaseous state, and nitrogen, all in an intensely hot condition. The production of carbonic acid may therefore be dispensed with (as a portion of the hot gaseous products of combustion are already in that state), provided the heat usually developed in its production and necessary for its conversion into carbonic oxide is compensated for by the heat brought in by the products of combustion. A producer so arranged will become a converter, in which the gaseous products of combustion will be reconverted into combustible gases without any diminution of the temperature of the solid fuel. Although such a result may appear at first sight paradoxical and unlikely, it has been proved by experience in the working of several furnaces during the past nine months, and may be explained by the presence in the burnt gases of a proportion of nitrogen large enough to carry the heat necessary for the reaction.

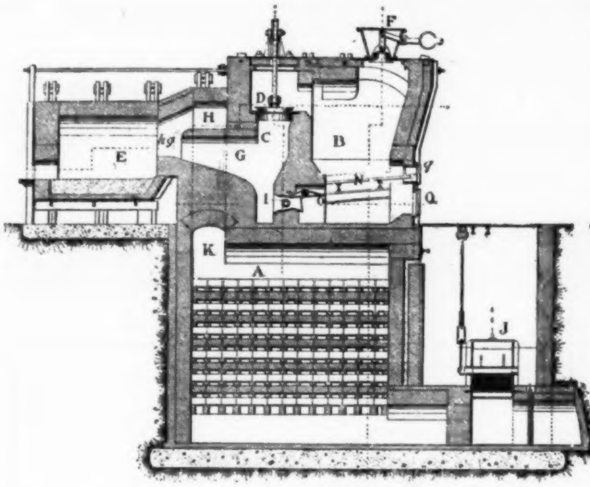


FIG. 1.

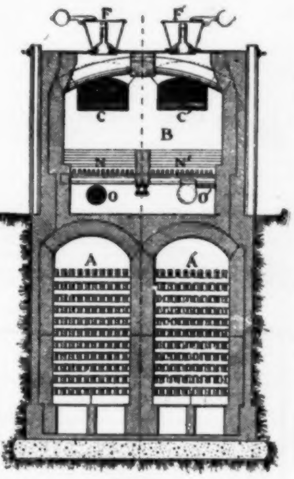


FIG. 2.

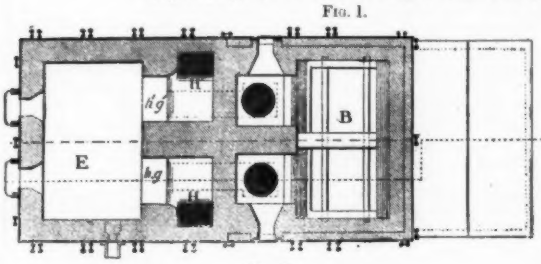


FIG. 3.

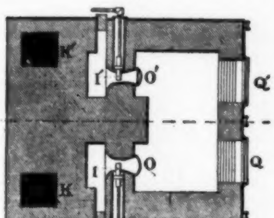


FIG. 4.

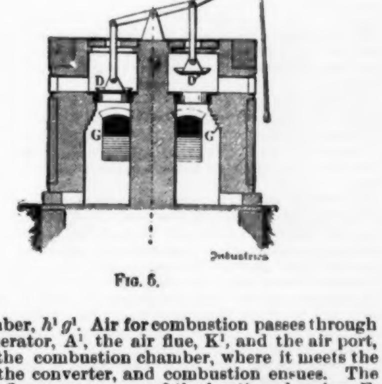


FIG. 6.

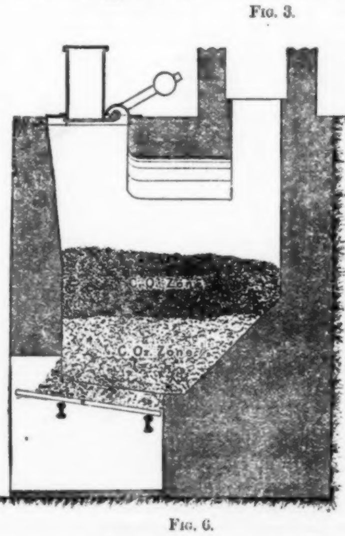


FIG. 6.

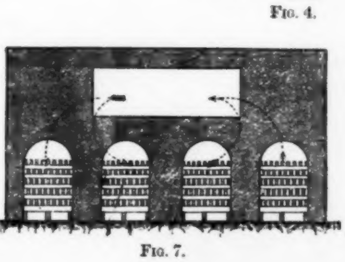


FIG. 7.

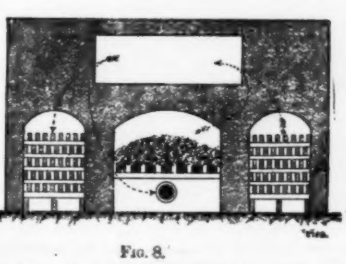


FIG. 8.

GENERAL VIEWS OF NEW FURNACE, SHOWING LONGITUDINAL AND TRANSVERSE SECTIONS AND SECTIONAL PLANS.

It is possible by a very simple reasoning to explain the cause and source of the economy realized in a new furnace. If oxygen be admitted below the grate of a gas producer filled with incandescent coke (Fig. 6), carbonic acid will be formed in the lower zone and produce a certain quantity of heat. This carbonic acid will be decomposed in the upper zone, and absorb a portion of this heat. From this reaction it is seen that the weight of carbon gasified in the lower zone is equal to that of the carbon gasified in the upper zone, and if we suppress the production of carbonic acid and replace it by superheated carbonic acid from an external source of supply, half the fuel should be saved.

The furnace about to be described is provided with air regenerators only, but must be distinguished from furnaces in which the air alone is heated. Such furnaces are necessarily wasteful, as only a portion of the heat contained in the burnt gases can be theoretically recovered, and such a result is not attainable in practice. In the new furnace, on the contrary, the gases leaving the furnace are partly directed below the grate of the converter producer and partly into an air regenerator, so that the whole of the heat is utilized as in the original Siemens furnace, but in a different manner. The air regenerators perform the same functions as formerly, but the heat which in the old furnaces was deposited in the gas regenerator is now utilized to bring about the conversion of the products of combustion into combustible gases, to distill the volatile material in the coal, and to raise these volatile constituents to a certain temperature before their arrival in the furnace chamber. The economy of the new Siemens furnace over the original form may rise as high as fifty per cent. when coke is the fuel employed. When coal is used the economy will be considerably increased, because the sensible heat of the gases necessarily lost in the original Siemens furnace is saved in this form, and the formation of tar and soot in the flues is avoided.

Figs. 7 and 8 show the relation which exists between the ordinary and the new type of Siemens furnace. In the first case the waste gases are directed through two regenerators, while in the second case the waste gases are partly directed through an air regenerator and partly through a converter producer. In both cases the waste heat from the furnace is entirely utilized, leaving only heat sufficient for chimney draught; but as in the new furnace a portion only of the products of combustion passes away by the chimney, while the remainder returns to the furnace after passing through the converter producer, the heat necessary for producing draught in the chimney is diminished to the same extent. This represents a further saving in fuel. As there is no gas regenerator in the new furnace, there is no loss of heat by radiation from it, and further economy is thereby also effected. In both furnaces there is reversal of the currents of air and gas so as to produce uniform diffusion of heat through the furnace chamber; in both, too, the air and gas are delivered into the furnace at a very high temperature.

The furnace may be constructed in various forms, the one shown in Figs. 1–5 having been used with success for heating and welding iron. It is a radiation furnace heated by means of a horseshoe flame; this form of flame offers advantages in this as in ordinary regenerative gas furnaces, but its adoption is not obligatory, as the flame may be made to traverse the heating chamber from end to end in the usual manner. The same letters indicate the same parts in all the figures. AA[1] are reversible regenerators for air, on the top of which is built the gas producer or converter, B, of which FF[1] are the charging hoppers and NN[1] the grates. The heating chamber, E, adjoins the producer and rests on the ground, or in some cases a pit may be provided below it. CC[1] are the flues leading the combustible gas to the furnace chamber, E, the passage of the gas in these flues being controlled by the valves, DD[1], at the two ends of a rocking beam, so that the outlets are opened and shut alternately to convey the gas to one or other of the ports, GG[1], of the heating chamber, E. HH[1] are the air ports of the heating chamber, communicating through the flues, KK[1], with the regenerators, AA[1]. II[1] are steam jets placed in the return flues for directing a portion of the waste products of combustion to the grates of the converter. J is the valve for reversing the direction of the air flowing into the furnace, and of the products of combustion through the regenerators to the chimney flue. OO[1] are hinged caps for alternately admitting and shutting off the products of combustion from the heating chamber to the converter. These caps are worked automatically by means of connections attached to the rocking beam, the same movement which closes D opening O[1], and that which closes D[1] opening O. Qq are doors for giving access to the grates of the converter for clearing them.

The *modus operandi* of the furnace is as follows: Gas from the converter, B, passes through the flue, C[1], and the valve, D[1], to the gas port, G[1], and into the combustion chamber, $h^1 g^1$. Air for combustion passes through the regenerator, A[1], the air flue, K[1], and the air port, H[1], into the combustion chamber, where it meets the gas from the converter, and combustion ensues. The horseshoe flame sweeps round the heating chamber, E, the products of combustion passing away by the second combustion chamber, *h g*, and going partly through the regenerator, A, and reversing valve, J, into the chimney flue and partly down the flue, G, whence they are drawn by means of the steam jet, I, through the capped inlet under the grates, NN[1], of the producer, B, there to be converted into combustible gases. From time to time the direction of the flame in the furnace is reversed by manipulating the rocking beam carrying the valves, DD[1], and the reversing valve, J, in the usual manner of working regenerative gas furnaces. An auxiliary steam jet is provided for the purpose of supplying atmospheric air to start the producer when the furnace is first heated up.

The new form of regenerative gas furnace has been applied in this country to the heating and welding of iron, to which uses its application is being extended in England and abroad, while furnaces are in course of construction to apply it for puddling iron and for copper and steel melting. Altogether, ten furnaces for these purposes are in course of construction, in addition to ten furnaces already at work for heating iron. The first furnace of this kind was constructed at the Pather Iron and Steel Company's works at Wishaw, for welding iron, and much credit is due to the proprietors for having had the enterprise and public spirit to make the first application of this improved regenerative gas furnace. The working has been eminently satisfactory from the commencement. The success of the first application of the furnace proves the correctness of the principle upon which it is constructed and the means adopted for carrying it out. The results of working during the past nine months have shown an average saving of five per cent. in waste on the weight of the iron heated, and a saving of upward of two-thirds of the weight of coal used, and a greater money saving, owing to the inferior quality of the fuel employed as compared with that used in their other furnaces fired with solid fuel. From the total saving thus realized should, however, be deducted the cost of raising steam, for which purpose the waste heat of the old furnaces is utilized. Allowing for separate boilers, the saving effected by the use of the new system in a furnace heating eight tons of iron per shift is nearly eighteen tons of coal per week, and the money saving in iron and coal exceeds £1,000 per annum.

This new furnace has also been recently applied for heating billets by the United Horse Shoe Company, of London, and in this case the results are quite as satis-

factory or even better than those just given, as is shown by the accompanying table:

Date.	Number of charges per shaft.	Duration of each shaft.	Weight of billets heated (30 in. by 2¾ in. by 2¾ ft.)	Average time required for heating to welding.		
1889.		a.m. p.m.	Minutes.	Tons	Cwts.	
Sept. 13..	11	5:45 to 5:25	21	8	16	a
Sept. 14..	6	6:00 to 12:15	20	4	16	b
Sept. 16..	11	5:45 to 5:30	21	8	16	c
Sept. 17..	11	5 45 to 5:30	23	8	16	d

Continued below.

	COAL.		
	Weight used.	Used per ton of billets.	Quality.
	Cwts.	Cwts.	
a	17½	1 9	Newcastle small.
b	8	1·7	Newcastle cobbles.
c	17¾	2·01	½ Newcastle small. ½ London screenings.
d	18¼	2·08	London screenings.

It will be noticed from these results that in this furnace eleven charges are made in less than twelve hours, each weighing about 16 cwt., and yielding in the finished state as horse shoe iron 15 cwt. per charge, or 8·25 tons in the day. The amount of small coal used was about 18 cwt. per shift. This is equivalent to 2 cwt. per ton of iron heated, which, it will be admitted, is a most satisfactory result; in one case the consumption of coal was even reduced to 1·7 cwt. per ton, each billet coming out at a full welding heat and rolling into a sound bar. The coal used each day is indicated in the table.

The following are analyses of gas made in the converters at Pather and in London respectively:

PATHER CO.		UNITED HORSE SHOE CO.	
From Wishaw coal (nuts).		*Newcastle cobbles.*	
CO_2	4·6	CO_2	4·5
O	nil	O	nil
CO	23·0	CO	22·5
H total	17·4	H	16·3
C vapor	1 5	CH_4	2 6
N	53·5	N	54·1
	100·0		100·0

From these analyses it will be seen that the proportion of CO_2 in the gas made in the converters is not greater than that made in the ordinary Siemens producer.

Besides the advantages in the saving of fuel and metal, it is desirable to call attention to the simplicity of design of the new furnace, owing to which its cost of construction is not much greater than that of a solid fuel furnace, while its cost of maintenance is very much less.

Its cost of construction is found to be about two-fifths of that of the old form of regenerative gas furnace, of the same productive capacity, with separate gas producers and gas regenerators, and the space occupied below ground is also considerably reduced. A saving of labor attends the employment of the new furnace, as, owing to the producer being connected with the furnace, the same men can attend to both, and the labor of firing is reduced in proportion to the reduced consumption of fuel.

In conclusion, the following advantages may be claimed for the new furnace as compared with solid fuel furnaces used for heating and welding iron, viz.: (1) A saving in fuel amounting to, say, two-thirds in weight, and after allowing for raising steam in separate boilers, this saving is fully equal to 5 cwt. of coal per ton of iron heated; (2) a reduction in the waste of iron equal to 5 per cent. upon the weight of metal heated; (3) a saving in labor and repairs which will probably compensate for the extra cost of the new furnace.

Taking a furnace to heat ten tons of iron per shift, or 110 tons per week, the following calculation gives the money saving realized by the adoption of the new furnace:

110 tons iron at 5 cwt. per ton = 27½ coals saved at 6s	£8 5 0
110 tons iron at 5 per cent. = 5½ tons iron at £4	22 0 0
Being	£30 5 0

per week, or say £1,500 per annum.

[Nature.]

NOTES ON A RECENT VOLCANIC ISLAND IN THE PACIFIC.

In 1867, H.M.S Falcon reported a shoal in a position in about 20° 20′ S. and 175° 20′ W., or thirty miles west of Namuka Island of the Friendly or Tonga Group.

In 1877 smoke was reported by H.M.S. Sappho to be rising from the sea at this spot.

In 1885 a volcanic island rose from the sea during a submarine eruption on October 14, which was first reported by the Janet Nichols, a passing steamer, to be two miles long and about 250 feet high.

The U. S. S. Mohican passed it in 1885, and from calculation founded on observations in passing, gave its length as 1 1/5 miles, height 165 feet. The crater was on the eastern end, and dense columns of smoke were rising from it.

In 1887 the French man-of-war Decres reported its height to be 290 feet.

In the same year an English yacht, the Sybil, passed it, and a sketch was made by the owner, H. Tufnell, Esq., which is here produced.

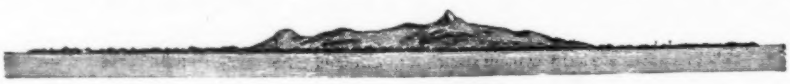
The island has now been thoroughly examined and mapped, and the surrounding sea sounded by H. M. surveying ship Egeria, Commander Oldham.

It is now 1 1/10 mile long and 7/8 of a mile wide, of the shape given in the accompanying plan. The southern portion is high, and faced by cliffs on the south, the summit of which is 153 feet above the sea. A long flat stretches to the north from the foot of the hill.

The island is apparently entirely formed of ashes and cinders, and a few blocks and volcanic bombs here and there, especially on the verge of the hill.

Under the action of the waves, raised by the almost constant southeast winds, this loose material is being rapidly removed; continual landslips take place, and Commander Oldham is of opinion that the original summit was some 200 or 300 yards southward of the present highest cliff, and that the shallow bank stretching to the south represents the original extension of the island.

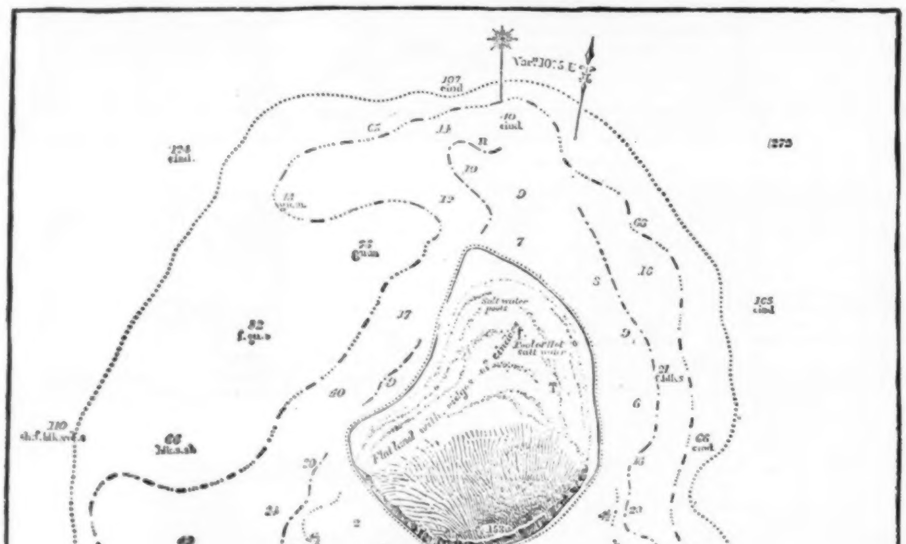
As far as can be judged from Mr. Tufnell's sketch from the northwest and that of the Egeria from the south-southeast, considerable changes have taken place in two years, the different summits shown in



By H. Tufnell, Esq., 1887, bearing S.E. about 2 miles.

By "Egeria," 1889, bearing E. 1½ mile.

By "Egeria," 1889, bearing N.N.W. ½ W. 1 mile.



the former having disappeared as the sea has eaten away the cliffs.

The flat to the north seems to be partly due to redistribution under the lee of the island of the material removed from the southern face. It is crossed by curved ridges from 3 to 12 feet high, which Commander Oldham considers to have been formed as high beaches during spring tides and strong winds, the flat ground between them, almost at the level of the water, being deposited under normal conditions of weather.

The island is thus gaining on one side while losing on the other, but when the high part is gone, this partial recovery will probably cease.

A little steam issuing from cracks in the southern cliffs was the sole sign of activity, but a pool of water at a temperature of from 91° to 113° F., water which rose in a hole dug in the flat of a temperature of 128° F., and a temperature of 100° F. in a hole dug half way up the slope, also show that the island still retains heat near the surface. The water is sea water that has filtered through the loose ashes, and it rose and fell with the tide.

It appears by the condition of the flat that the island has neither risen nor subsided during the past two or three years.

It will be interesting to watch the ultimate fate of this last addition to the Pacific isles, but it seems probable that its existence as an island will be short unless a hard core is yet revealed.

The soundings between Falcon Island and Namuka show that they are separated by a valley 6,000 feet deep.

Metis Island, 73 miles north-northeast of Falcon Island, is another volcanic cone that appeared a few years before the latter, but has not yet been examined.

W. J. L. Wharton.

HIGH ALTITUDES OF SOUTHERN CALIFORNIA.

By Walter Lindley, M.D.

August 26, 1888, in company with a friend, I left Los Angeles for the San Jacinto mountains. A four hours' ride by rail took us to the town of San Jacinto, where we were met by a patient of mine whom I had considered to be at death's door from phthisis. He was a post office clerk in Kansas City, and came to me nearly four years ago with daily rise of temperature to 103°, night sweats, hard cough, purulent expectoration, marked emaciation, dullness in left apex, *rales* quite general over both lungs. He remained quite close to the coast for a year, but lost ground, and suddenly determined to go to San Jacinto, where he "took up" a piece of government land. There was a steady improvement almost from the first. He has this season worked in the hay field. While he is by no means a well man, yet the change for the better has been wonderful. San Jacinto has an altitude of about 1,400 feet. It is too warm for comfort in the summer, yet numerous consumptives claim they gain most during the hot season. Here we hired two horses and a buggy for $3.50 per day, and drove ten miles to the east, to what is called "the foot of the grade," where we stayed over night. The accommodations would have been real good but for the fact that the beds were all engaged. The consequence was we had to sleep on a straw pile in the barn, but the food was good, and, like the straw, was clean.

At 5 o'clock A.M. the next day we started up the grade. The rise is said to be about thirty-three feet in a hundred. A six-mule team has all it can do to haul 800 pounds up this steep road. The grade is two and a half miles long, and it usually takes at least three

hours for a mule team to reach the top. It seemed to be the business of every person we met to try to frighten us, and we came near not attempting to drive up, but finally did try, and our little team pulled us up in just an hour. We gave them a rest about every twenty yards. Once in a while, when we dared to take our eyes from our horses, we would glance back at the magnificent landscape below us.

When we arrived at the top of the grade, we found ourselves at an altitude of 5,200 feet, and in the edge of a beautiful forest of towering pine and fir. For four and a half miles we drove over a charming road aligned by the refreshing green trees, enswarded by grasses, bushes, and many varieties of flowers—the rose and wild fuchsia predominating. Our horses slaked their parched throats and cooled their dry and heated feet in a musical mountain stream. The blue bird, the mocking bird, and the quail were omnipresent, while the road walker, with his long tail, marched along majestically before us, and the gray squirrel ran into his hole near the top of the tree. The sun rose as we drove, and we felt that we were indeed in the heights. The cool, invigorating atmosphere, brought to us through the pine boughs by a gentle breeze, fanned our foreheads and filled our lungs.

A few cabins picturesquely located indicated that our morning drive was ended. It was 7:30 o'clock when we sat down with excellent appetites to a rural breakfast of oatmeal mush, bread, milk, ham, butter, and coffee, all of the best quality, in a primitive hotel.

Here we passed a delightful, dreamy day. The place is called Strawberry Valley. About two hundred persons were living here in tents and cabins, but they all leave by the middle of October. Then the snows begin. Consumptives and asthmatics are here in considerable numbers, and when the snows fall they hasten to the valley, 3,500 feet lower. We made arrangements to go to the peak of Mt. San Jacinto, 11,100 feet high, accompanied by Warner, the guide. Bright and early we were up the following morning, and soon had our horses packed for going up the trail, but alas for the propositions of man! Our horses began to buck and run around in a circle, and soon our well arranged packs were flying in all directions. Strange to say, this discouraging episode evoked expressions of unbounded mirth from all of the campers, who had gathered to see our brilliant cavalcade depart on its adventurous mission. I very much feared that such convulsive laughter would cause a hemorrhage from the lungs of some the valetudinarians who stood gaping on. How sad that would have been! We saw that our mistake was in not asking to have saddle horses hitched to the buggy at San Jacinto. I would advise persons making this trip to insist on having saddle horses, and have saddles put in the buggy to use when Strawberry Valley is reached.

We soon secured another horse and a burro and were fairly started by eight o'clock. It is fifteen miles from Strawberry Valley to the peak. The first three miles is through rolling pine forests by a mountain stream. Then we began to climb, and for an hour we were going upward until we reached the Tauqwitz Valley, 7,500 feet high. Here again were thousands and thousands of acres of pine forests, and rich land well watered by never-failing mountain springs. In the center of this valley there is a peat bog. The horses passed readily through it, but the burro on which, to my regret, I was mounted absolutely refused to take a step in the yielding, marshy, grass-covered bog. As I sat there whipping, coaxing, and hallooing, all to no purpose, I might well have been dubbed, like Don Quixote de la Mancha, the Knight of the Sorrowful Figure. By going a circuitous route I avoided the swamp, and we were soon climbing higher and higher; we went until we passed over a ridge and into another magnificent combination of forest and grassy plain called

TAMARACK VALLEY.

Here we were 9,000 feet above the level of the sea. As we passsd through a beautiful meadow where the foot of man had rarely trod, a deer ran before us and was soon hidden in the timber. Again, after about four miles ride we began to climb; as we crossed the last mountain stream at about five P. M., we filled our canteens and watered our horses. At six P. M. we reached a level plateau 10,300 feet above the level of the sea, and only 800 feet below the peak. Here we were to spend the night. Soon we noticed the effect of the rarefied air. As I assisted in getting logs together for a fire, I found that walking ten yards exhausted me, and gave me the sensation of having climbed rapidly two or three flights of stairs. My heart beat at the rate of 108 per minute. Our guide was an intelligent young law student from Frankfort, Indiana. Over two years ago he began having hemorrhages of the lungs, and a year ago last April, while unable to sit up, was brought by a brave sister to Southern California. Tenderly and anxiously she cared for him in that long and tedious journey toward a forlorn hope. He improved from the time they reached California, and they soon came camping to Strawberry Valley, where he gained rapidly. In the autumn they went down to the town of San Jacinto, where the young man was able to clerk in the bank. When May came, they again came to Strawberry Valley, and the brave and independent young sister rented the hotel which she now manages in such a successful manner, while the young man acts as guide for parties wishing to kill game or explore the mountains. Strange to say, his pulse was only 60 per minute. He did not seem near as much distressed as my friend and I. Our evening meal was soon prepared, and never were fried bacon, potatoes and good bread, butter and tea more enjoyed. We unrolled our blankets and lay down under an immense pine tree. The novelty of the situation and the peculiar atmosphere prevented us from sleeping very soundly, and during the night we would from time to time be startled from our slumbers, but the intense stillness and the sight of the Pleiades, that watched directly over our improvised bed, would reassure us, and we would soon be dreaming of bears, deer, mountains, and burros.

At four o'clock in the morning we were up. After feeding our horses and eating a sandwich, we started up the last peak. We reached the very top in time to witness the sun rise in his splendor from beyond the Colorado Desert, that lay spread out below us in its stupendous barrenness. What is that dark, twisting object, about the size and apparently traveling at about the gait of a snail? It comes nearer, and we see that it is a freight train on the Southern Pacific Railroad near Indio. The guide starts a bowlder over the eastern slope of the mountain, and we hear it bounding through the awful chasms below. From this peak the ocean can be plainly seen. But space will not permit me attempting a description of what we saw from this wondrous height. On the topmost rock is a fruit jar, with a cover carefully fitted with rubber, in which every visitor is expected to leave his card, with address and date of visit. The name of Doctor McLean, of Riverside, alone represented the medical profession, and I proudly put in mine as the second in the list.

Our trip back to Strawberry Valley was enlivened by a mountain thunder and hail storm, but the fir trees were like umbrellas, and protected us.

This trip again revealed to me the wonderful variety of the Southern California climate. If an altitude of 1,400 feet is needed, it is to be found at the town and vicinity of San Jacinto; while at Strawberry Valley there is an atmosphere redolent with the fragrance of the pine forests, and an altitude of 5,200 feet. At Tauqwitz Valley are all these beautiful surroundings and an altitude of 7,500 feet, and at Tamarack Valley we have again the running streams, the beautiful meadows, great trees, and an altitude of 9,000 feet.

In all these valleys the atmosphere is cool in midsummer, and there is an abundance of game.

To the weary physician who desires for a few days to absent himself from the busy hum of the world, I can heartily commend these mountain valleys for quiet, comfort, and grandeur.

Aside from the value of these elevated valleys as summer resorts, I believe they will become even more sought after as winter resorts.

The Alpine winter cure of pulmonary diseases is very popular in Great Britain and on the Continent. Thousands of consumptives flock to the Davos-Platz and Maloja Plateau in the Swiss Alps every winter. Immense and well arranged hotels have been constructed by rich companies, and wonderful results have been recorded.

The following are the altitudes of the chief resorts:

SWISS ALPS.*

	Feet.
Maloja	6,000
Wiesen	4,771
Davos	5,105
Andermatt	4,738

SOUTHERN CALIFORNIA MOUNTAINS.†
(SAN JACINTO.)

	Feet.
Strawberry Valley	5,200
Tauqwitz Valley	7,500
Tamarack Valley	9,000

From the illustrations I have seen of these Alpine resorts, I judge they are naturally barren plateaus, and have not the wealth of beautiful pine forests that the Southern California valleys I have so meagerly described contain. The advantages of the pine forests are:

1st. Giving a medicated air for constant inhalation.
2d. Adding beauty and picturesqueness to the scenery.
3d. Protecting the valleys from winds.

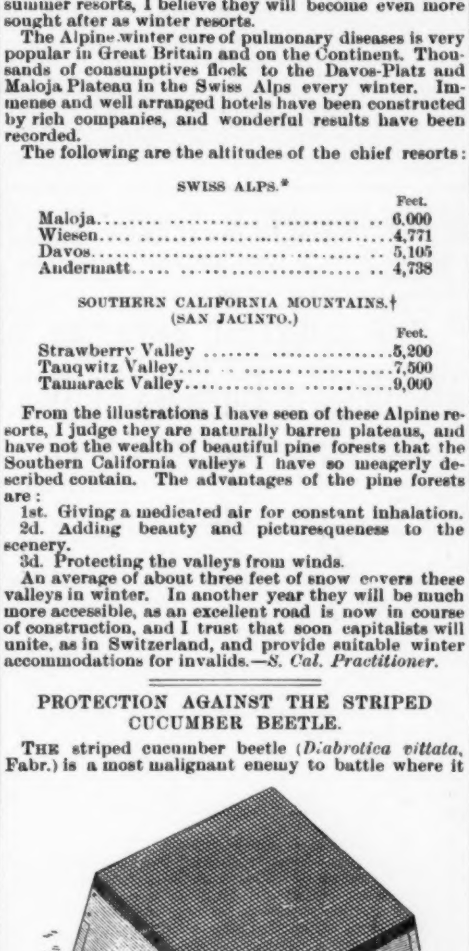
An average of about three feet of snow covers these valleys in winter. In another year they will be much more accessible, as an excellent road is now in course of construction, and I trust that soon capitalists will unite, as in Switzerland, and provide suitable winter accommodations for invalids.—*S. Cal. Practitioner.*

* "Alpine Winter in its Medical Aspects." By A. Tucker Wise, M.D. London: J. & A. Churchill, 1886.

† Approximate.

PROTECTION AGAINST THE STRIPED CUCUMBER BEETLE.

THE striped cucumber beetle (*Diabrotica vittata*, Fabr.) is a most malignant enemy to battle where it



A SIMPLE PLANT PROTECTOR.

has once gained possession of the field. The oft-printed formulas that abound in our horticultural journals generally prove signal failures when put to the test in anything like a severe attack. At best, applications to the foliage are expensive and more or less detrimental to the plants. Gardeners and entomologists are at last pretty well agreed that some protection placed over the hill before the plants appear above ground will prove most satisfactory in the long run. The fact that such protection often aids materially in preventing injury from frost is an important point in its favor, as the *Cucurbitaceæ* are among our tenderest open air plants.

The protector illustrated in the accompanying sketch has the merit of being strong, light, durable, and economical of storage, as well as being entirely efficient and cheap. The difficulty with most of the plant protectors in use is that they are too fragile, too costly, or too bulky for convenient storage. The one here shown is made of five-eighth inch undressed pine lumber, covered over the top with ordinary wire mosquito netting. The frame may be made sixteen inches square at the top, and the sections are cut so that the bottom is slightly larger, giving flare enough to admit of nesting the boxes together for convenient storage. By cutting the boards in the manner shown in the drawing, they may be "doubled nailed," which greatly adds to the strength of the frame without increasing the weight or cost.—*E. S. Goff, University of Wisconsin, Madison, Garden and Forest.*

CACAO.*

CACAO, the chocolate bean, is an even more profitable crop than coffee, and its price is fixed—almost as fixed as that of gold. In some portions of Venezuela cacao beans are still used as legal tender, and in many of the smaller towns customers at market have to take them in lieu of small change, as they use rolls of bread in Ecuador. Coffee was introduced into South America from Arabia by the Franciscan monks, but cacao was indigenous to the soil, and was used in large quantities by the Indians for food at the time of the discovery. It was not liked by the Spaniards at first, but was introduced into France by the Franciscans, who were always very enterprising fellows, and the French cooks at once adopted it into great favor. Cardinal Richelieu is said to have been the first chocolate drinker of any fame, and to have set the fashion of using it.

There are two kinds, the native cacao, called El Criollo, and an imported plant called El Trinitario, that was brought to the country from Trinidad and other of the West India Islands. The former is of greatly superior quality, and is scarce. Not more than 5,000 or 6,000 bags are raised annually, and it is worth from $32 to $35 gold a bag of 110 pounds. Of the Trinidad variety about 100,000 bags are raised, and it sells for $18 to $20 a bag. The native plant requires peculiar soil and care, and grows best in the hottest and most unhealthful regions, so that there is not much comfort in its cultivation. The cacao plantations are found all along the coast of Venezuela, and are more profitable than coffee, on account of their requiring less attention, as well as because of the greater value of the crop.

The cacao tree, for proper development and remunerative crops, requires a temperature of at least 80° Fahrenheit. Hence the area of the cacao belt is comparatively restricted. Besides the conditions of temperature, this crop needs a moist soil and humid atmosphere, and so the lands along the coast of the Caribbean Sea, sloping from the mountain tops to the shore, bedewed by the exhalations from the sea and irrigated by the numerous rivulets that course down the valleys, are found to be, in all respects, well adapted to the profitable cultivation of cacao. And while the lands in the interior possessing facilities for irrigation may be said to be equally as good for the purpose, yet the absence of roads and the consequently difficult transportation of produce on the backs of donkeys over the rugged mountain paths materially reduce the profits on the crop before it reaches the market.

A cacao plantation is set in quite the same manner as a coffee orchard, except that the young stocks may be transplanted from the nursery after two months' growth. No preparation of the soil is deemed necessary, and no manures are applied. The young trees are planted about fifteen feet equidistant, which will accommodate 200 trees to the acre. Between the rows and at like spaces are planted rows of the bacuara tree, that serve to shade the soil as well as to shield the young trees from the torrid sun. Small permanent trenches must be maintained from tree to tree throughout the entire length of the rows, so that at least once in each week the stream descending from the mountains may be turned into these little channels and bear needful moisture to the trees and soil. At the age of five years the plantation begins to bear fruit, and annually yields two crops, that ripening in June being termed the crop of San Juan, and that maturing at Christmas being known as the crop of La Navidad. The average age to which the tree attains, under proper care, may be estimated at forty years, during which period it will give fair to full crops of fruit, but of course it must be understood that, as in our fruit orchards, a new tree must be set from time to time, to replace one that may be decayed or blighted. The average crop of the cacao plantation, at ten years of age and under a proper state of cultivation, will amount to 500 to 600 pounds an acre.

The fruit or seed of the cacao, in form, size, and color, is quite similar to the almond. These seeds, to the number of sixty or eighty, are incased in a pod that, except in color, is the counterpart of a young muskmelon, being elongated and ribbed in the same manner. Its color, when green, is like that of the egg plant, but on ripening it assumes a reddish hue. A peculiarity of the cacao is that it bears fruit from the ground up, the trunk of the tree yielding fruit as well as the branches. Upon ripening, the pods are gathered from the trees and heaped in piles on the ground, where they are left for some days to ferment, after which they burst open, when the seed must be shelled out. After a light exposure to the sun, during which time great care must be taken to protect them from the rain, they are packed and ready for market.

The good people down there say that all the best cacao goes to Europe, and not a pound of El Criollo to the United States. They say, too, that we eat the miserable product of Mexico, Brazil, and the Central American States, which does not approach in quality the Venezuelan fruit, and even then our manufacturers adulterate it so that it does not taste naturally. And it does not require an expert to detect the difference between a piece of Venezuelan chocolate and a piece of Mexican or Brazilian. It is an actual fact that you can buy chocolate in the United States at the high-priced retail stores for about half the money that is charged you at the Caracas factories. The best in Caracas is eighty cents a pound at the factories, and the retailers charge about $1 for it. You can get a superior article for sixty cents, and the ordinary makes are fifty cents a

* From a report of travels through South America, by William E. Curtis.—*Western Druggist.*

pound. None can be had less than that, while in the United States it can be bought at all the groceries for twenty-five, thirty and forty cents a pound. The Caraquenians say that our manufacturers cannot possibly produce an honest cake of chocolate for that price, but adulterate it with pipe clay, flour, and other foreign substances.

ON THE ROTATION OF MERCURY.

NEARLY a century has elapsed since Schröter published his first observation of the physical aspect of Mercury, and assigned to the planet a period of rotation; but it has been left to that perspicacious observer, Signor Schiaparelli, to demonstrate the fact by a series of remarkable observations given by him in *Astronomische Nachrichten*, No. 2944. The observations extend from 1882 to the end of last year. As many as 150 drawings have been made of the markings upon the planet with respect to the best positions for observation. It is noted that one of the finest drawings was made on August 11, 1882, when Mercury was only 3° 2′ from the sun's limb. The markings that are visible on Mercury when observed at the same hour on consecutive days are identical in their aspect, and this being so, three hypotheses have been propounded (*Astr. Nach.*, 2479) regarding the rotation of the planet, viz.:

That (1) the time of rotation is about 24 hours.

(2) The planet makes two or more rotations in the same interval.

(3) The time of rotation is so slow as to be inappreciable when observing the markings during a few days.

Schröter decided in favor of the first hypothesis, and Bessel, from a discussion of this observer's data, determined the time of rotation to be 24h. 0m. 52·97s. Schiaparelli's observations support the last of these hypotheses, and are opposed to the rotation period determined by Schröter.

Following a series of dark markings shown in the figure which accompanies the article, it was found that—

Mercury revolves round the sun in the same manner that the moon revolves round the earth, always presenting to it the same hemisphere; hence, since the planet's periodic time is 87·9693 days, this must be the time of rotation on its axis.

The dark markings observed appear extremely faint, and are not easily recognized. On good occasions the color may be seen to be reddish brown, and always differs from the general color of the planet's disk, which is a bright rose changing to copper.

This most interesting and important communication from Milan Observatory must be read in detail in order that it may be appreciated.—*Nature.*

RECENT OBSERVATIONS OF JUPITER.

OBSERVATIONS of Jupiter have been conducted under great difficulties during the past opposition, in consequence of the low altitude of the planet. His elevation, even at meridian passage, has only been about 16°, as observed in this country, so that the study of his surface markings has been much interrupted by the bad definition which usually affects objects not far removed from the haze and vapors on the horizon. It is, however, important that planetary features, especially those which exhibit changes of form and motion, should be watched as persistently as circumstances allow, and with this purpose in view Jupiter has been submitted to telescopic scrutiny whenever the atmosphere offered facilities for such work during the past summer and autumn. Few opportunities occurred, however, during the latter season, owing to the great prevalence of clouds, and on the several nights sufficiently clear for the purpose, the atmosphere was unsteady and the definition indifferent; thus the more delicate lineaments of the planet's surface could be rarely observed with satisfactory distinctness.

The great red spot was visible on the night of May 21, 1889, and it was estimated to be on the central meridian at 12 h. 31 m. Further views of the same object were secured in June, July, and later months. In appearance and form it presented much the same aspect as in preceding years. Its elliptical outline is still preserved, and there seems to have occurred no perceptible change in its size. It is somewhat faint relatively to the very conspicuous belts north of it, and it is only on a good night that it can be well recognized as a complete ellipse with a dusky interior. On the evening of September 12 last, I obtained an excellent view of it with my 10 inch reflector, power 252. The spot was central at 6 h. 33 m., and its following end was seen to be much the darkest. This has usually been the case, and I have often noticed a very small black spot at this extremity. Another observation was effected on the early evening of November 26, when the spot crossed the planet's center at 3 h. 54 m., but the exact time was a little uncertain, the conditions being far from favorable. Possibly the spot may have effected its passage a little before this time, as, from several views of the following end of this object at about 4 h. 30 m., I concluded my estimate might be a trifle late, but in any case the error would be small.

Comparing the observation on November 26 with that recorded on May 21, it will be found that in the interval of 188·64 days the red spot completed 456 rotations, and that its mean period was 9 h. 55 m. 40·15s. This is nearly identical with the rotation period I found for the same object in 1888, when it was 9 h. 55 m. 40·24 s. (462 rotations), and in 1887, when the figures were 9 h. 55 m. 40·5 s. It is evident from these several determinations that during the last three oppositions the motion of the spot has been a slight acceleration perhaps in velocity, inducing the rotation period to become a little shorter, but the differences are so small that they may well be covered by the observational errors which cannot be altogether eliminated from work of this character, and particularly at a time when the object observed is unfavorably placed. In any case the red spot has rotated with more celerity during the last year or two than in 1886, when its mean period was 9 h. 55 m. 41·1 s., to which it had gradually increased from 9 h. 55 m. 34·2 s. in 1879-80. These variations of motion may be regularly effected in a cycle, and it will be very important if future observations can determine the exact period.

The white spots near the equator of Jupiter are still occasionally visible, but it has not been feasible to secure views of them of a sufficiently exact nature to deduce their rotations. In recent years the apparent velocity of these objects has been decreasing, for while in the autumn of 1880 their period was 9 h. 50 m. 6 s., it was found, from many observations of similar markings by Mr. A. Stanley Williams, of Brighton, in 1887, that it had increased to 9 h. 50 m. 22·4 s.

Since 1884 a number of white spots have been also observed on the northern borders of the great northern equatorial belt. The period of these is but very slightly less than that of the red spot. On September 12, I observed one of these situated in a longitude not far preceding the west end of the red spot, and it appeared to have divided the equatorial belt with a vein of bright material. There was another object of the same kind following the red spot, but in this case the continuity of the belt was not interrupted, the bright matter appearing as a slight indentation in its northern side. These markings are shown in a drawing of Jupiter made by Mr. Keder with the great Lick refractor, power 315, on September 5 last, but they are not delineated in quite the same characters as seen here. The drawing alluded to is perhaps the best and the most replete with detail of any I have ever seen of this planet, and it furnishes clear testimony that the defining properties of the 36 inch telescope are of the highest order.

The curiously curved belt immediately north of the red spot is still one of the most prominent features on the planet's disk. It forms the southern half of the great south equatorial belt, which is double. Under the ends of the red spot it suddenly dips to the north and runs into the other half of the belt. In recent years the curved belt has been very dark and pronounced in the region contiguous to the following end of the red spot, and upon its crest there have been condensations of extremely dark matter. Under the preceding end of the spot this belt is, however, more delicate in tone, and it looks like a mere pencil shading.

During the few ensuing years these interesting features may be studied to greater effect, as the planet will assume a more northerly position, and rise above the vaporous undulations which have recently much interfered with observations of his surface.—*W. F. Denning, in Nature.*

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